Choosing the Wrong Portfolio of Projects

5 Reasons Organizations Choose the Wrong Projects (and What to Do About It)

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Abstract

There are five major reasons that organizations choose the wrong projects: (1) biases and errors in judgment, (2) failure to establish an effective framework for project portfolio management, (3) lack of the right metrics for valuing projects, (4) inability to assess and value risk, and (5) failure to identify project portfolios on the efficient frontier.

As a consequence of these shortcomings, organizations underestimate the value derived from projects; conduct too many small, low-value projects; don't kill failing projects soon enough; unknowingly take on high-risk projects; make project choices based on political considerations not in the best interest of the enterprise; and use inefficient decision-making processes that discourage trust and honesty. By my estimate, such problems cause organizations to obtain only about 60% of the value that could be derived from their project portfolios.

Methods are available for overcoming the reasons organizations choose the wrong projects. Success requires cultural change, organizational re-engineering, improving decision-making competencies, and institutionalizing best-practice analytic tools that fit the organization and its needs. Organizations that address the reasons for choosing the wrong projects can dramatically improve performance and create a significant, competitive business advantage.
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Errors and Bias in Judgment

Why do we need decision aids? Can't people make good choices on their own? Like many decision analysts, I was first attracted to the science of decision making as a result of reading about the errors and biases that affect people's judgments. Remarkably, it appears that our brains have been hard-wired to make certain kinds of errors. Hundreds of different biases have been identified and categorized, including biases that distort our judgments, that introduce errors into the estimates and forecasts that we produce, and that cause us to make the wrong choices.

If you're not already familiar with the major results from this fascinating field of research, this introduction should help you to appreciate the value of formal decision-aiding tools. Without the assistance of such tools, the decisions made within organizations, including choices of which projects to conduct, will be systematically biased. Errors and bias in judgment is the first reason that organizations choose the wrong projects.
Heuristics and Judgmental Biases

The fact that people's intuitive decisions are often strongly and systematically biased has been firmly established over the past 50 years by literally hundreds of empirical studies. Psychologist Daniel Kahneman received the 2002 Nobel Prize in Economics for his work in this area. The conclusion reached by Kahneman and his colleagues is that people use unconscious shortcuts, termed heuristics, to help them make decisions. "In general, these heuristics are useful, but sometimes they lead to severe and systematic errors" [1].

Understanding heuristics and the errors they cause is important because it can help us find ways to counteract them. For example, when judging distance people use a heuristic that equates clarity with proximity. The clearer an object appears, the closer we perceive it to be. Although this heuristic is usually correct, it allows haze to trick us into thinking that objects are more distant than they are. The effect can be dangerous. Studies show people often drive faster in fog because reduced clarity and contrast make going fast appear slower. Airline pilots are similarly tricked, so pilots are trained to rely more on instruments than on what they think they see out the cockpit window.

![Figure 1: Haze tricks us into thinking objects are further away.](image)

Some of the dozens of well-documented heuristics and related errors and biases are summarized in the table below.
<table>
<thead>
<tr>
<th>Comfort Zone Biases</th>
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<th>Motivation Biases</th>
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<tr>
<td>People tend to do what's comfortable rather than what's important.</td>
<td>People's beliefs are distorted by faulty perceptions.</td>
<td>People's motivations and incentives bias their judgments.</td>
<td>People use flawed reasoning to reach incorrect conclusions.</td>
<td>Group dynamics create additional distortions.</td>
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<tr>
<td>People: Become attached to the status quo. Value things more highly if they already own them. Seek information that confirms what they already suspect. Ignore information inconsistent with their current beliefs. Are more likely to choose an alternative if it is not the most extreme one considered. Make choices or predict outcomes based on what is pleasing to imagine rather than on rational evidence. Fail to learn and correct their beliefs despite strong evidence that they should. Keep doing the same things, even if they no longer work. Distort their views of reality in order to feel more comfortable.</td>
<td>People: See things according to the conventions of their profession, ignoring other views. Overlook and ignore unexpected data. See patterns in data where none exist. Anchor on information that is readily available, vivid or recent. Make insufficient adjustments from their initial anchors. Ascribe more credibility to data than is warranted. Overestimate what they know. Underestimate the time/effort to complete a difficult task. Perceive recent events as more distant and very distant events as less distant. Give different answers to the same question posed in different contexts.</td>
<td>People: Behave differently when they think they are being observed. Unconsciously distort judgments to &quot;look good&quot; and &quot;get ahead.&quot; Remember their decisions as better than they were. Take actions as if concerned only with short-term consequences. Attribute good decisions to skill, bad outcomes to others' failures or bad luck. Escalate commitments to avoid questioning earlier decisions. Favor actions that shield them from unfavorable feedback. May have the urge to do the opposite of what is suggested to resist a perceived constraint on freedom of choice.</td>
<td>People: Believe they can control outcomes that they can’t. Simplify inappropriately. Are persuaded by circular reasoning, false analogies, and other fallacious arguments. Are surprised by statistically likely &quot;coincidences.&quot; Base the credibility of an argument on its manner of presentation. Abhor risk but seek bigger risks to avoid a sure loss. Disregard probabilities when making decisions. Prefer eliminating a small risk to reducing a large risk. Think an unusual string of random outcomes (e.g., “heads”) makes that outcome more likely in the future. Cannot solve even simple probability problems in their heads.</td>
<td>Groups: Give preferential treatment to those perceived to be group members. Reinforce their beliefs via the bandwagon effect. &quot;Dive in&quot; when solving problems without having all the necessary information. Are excessively cautious in sharing data. Assume they agree when they don’t. Avoid expressing inconsistent, opposing views. Jump to conclusions prematurely or get bogged down trying to reach agreement. Discount solutions “not invented here.” Create illusions of invulnerability and ignore external views of the morality of their actions.</td>
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The following summary, including ideas for countering biases, is derived from some of the many excellent papers on the subject, especially the popular 1998 Harvard Business Review article by Hammond, Keeney, and Raiffa [2].

**Status Quo Bias**

Status quo bias refers to the tendency people have to prefer alternatives that perpetuate the status quo. Psychologists call this a "comfort zone" bias based on research suggesting that breaking from the status quo is, for most people, emotionally uncomfortable. It requires increased responsibility and opening oneself up to criticism. For example, if you are a company executive considering introducing a lower-cost/lower-quality version of an existing product to your product line, you face the risk of adversely affecting the perceptions of customers who choose your high-quality products. If your company's reputation for quality declines, you could be accused of making a bad choice. Just considering the change forces you to confront the trade-off between increased profits and the risk of damaging your brand image. Sticking to the status quo is easier because it is familiar; it creates less internal tension.

Admittedly, there are often good reasons for leaving things unchanged. But, studies show that people overvalue the status quo. A famous experiment involved randomly giving students a gift consisting of either a coffee mug or a candy bar. When offered the opportunity to trade, few wanted to exchange for the alternative gift. It is unlikely, of course, that students who naturally preferred the coffee cup to the candy bar received their preferred gift by chance. Apparently, "owning" what they had been given made it appear more valuable.

The power of this bias was quantified in a related experiment. Students were randomly chosen to receive mugs. Those with mugs were asked to name the minimum price at which they would sell their mugs. Those without were asked to name the maximum price at which they would buy. The median selling price was more than twice the median offer price. Again, ownership increased perceived value. Sometimes referred to as the "endowment effect," this bias may help explain why investors are often slow to sell stocks that have lost value. Likewise, it might be a factor for explaining why executives may have trouble terminating failing projects.

Social norms tend to reinforce preference for the status quo. For example, courts (and many organizations) view a sin of commission (doing something wrong) as more serious than a sin of omission (failing to prevent a wrong). As another example, government decision makers are often reluctant to adopt efficiency-enhancing reforms if there are "losers" as well as "gainers." The status quo is seen as fair; any change is seen as unfair. The burden of proof is on the side of changing the status quo.

Lack of information, uncertainty, and too many alternatives promote holding to the status quo. In the absence of an unequivocal case for changing course, why face the unpleasant prospect of change? Thus, many organizations continue to support failing projects due to lack of solid evidence that they've failed.
Killing a project may be a good business decision, but changing the status quo is typically uncomfortable for the people involved.

What causes status quo bias? According to psychologists, when people face the opportunity of changing their status quo, the loss aspects of the change loom larger than the gain aspects. Losses represent the certain elimination of visible, existing benefits. Gains, in contrast, are prospective and speculative. We know what we have, who knows what we will get? We fear regret, and this fear is amplified by our desire to maintain the respect and approval of others. In business, the key to success is often bold action, but for many CEO’s, the only thing worse than making a strategic mistake is being the only one in the industry to make it. Sticking with the status quo is safer.

The best advice for countering the bias toward the status quo is to consider carefully whether status quo is the best choice or merely the most comfortable one:

- When you hear comments like "let's wait and see" or "let's meet next month to see how the project is going," ask yourself whether you're hearing status quo bias.
- Think about what your objectives are and whether they are best served by the status quo or a change.
- Identify who might be disadvantaged by changing the status quo, and look for ways to mitigate or compensate for those disadvantages.
- Ask yourself whether you would choose the status quo alternative if, in fact, it wasn’t the status quo.
- Avoid overestimating the difficulty of switching from the status quo.
- Actively manage migration away from the status quo—communicate dissatisfaction with the status quo and repeat the message about the need for change.
- Note that a change becomes the status quo over time. Evaluate alternatives in terms of how they will be viewed in the future as well how they are perceived in the present.

**Sunk Cost Bias**

We know rationally that sunk costs—past investments that are now irrecoverable—are irrelevant to current decisions. Sunk costs are the same regardless of the course of action that we choose next. If we evaluate alternatives based solely on their merits, we should ignore sunk costs. Only incremental costs and benefits should influence our choices.

Yet, the more we invest in something (financially, emotionally, or otherwise), the harder it is to give up that investment. For example, when making a telephone call, being on hold and hearing the recording, "Your call is important to us...Please stay on the line," often means that you've got a lot longer to wait. Still, having already invested the effort to make the call, it's hard to hang up and call another time.

There is a great deal of research demonstrating the influence of sunk costs. In one study, students were shown to be more likely to eat identical TV dinners if they paid more for them. Another study arranged to have similar tickets for a theater performance sold at different prices—people with the more expensive tickets were less likely to miss the performance. A third study found that the higher an NBA basketball player is picked in the draft, the more playing time he gets, even after adjusting for
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differences in performance.

The Concorde supersonic airplane is often cited as an example of sunk cost bias. It became obvious early on that the Concorde was very costly to produce and, with limited seating, was unlikely to generate adequate revenue. Few orders for planes were coming in. Still, even though it was clear that the plane would not make money, France and England continued to invest. An example of sunk cost bias?

Sunk cost reasoning shows up frequently in business. For example, you might be reluctant to fire a poor performer you hired in part because you may feel to do so would be an admission of earlier poor judgment. You might be inclined to give more weight to information you paid for than to information that was free. You might find it harder to terminate a project if you’ve already spent a lot on it.

Why is it so difficult to free oneself from sunk cost reasoning? Many of us appear to be born with strong feelings about wasting resources. We feel obligated to keep investing because, otherwise, the sunk cost will have been “wasted.” We would then need to admit (at least to ourselves if not to others) that we made a mistake. It has even been suggested that sunk cost reasoning may be a kind of self-punishment. We may unconsciously force ourselves to follow through on commitments that no longer seem desirable in order to instruct ourselves to be more careful next time.

Techniques for countering sunk cost bias include:

- Ask yourself what another manager would do in your place, one without a prior history in the investment.
- Seek the opinions of people who were uninvolved in the original choice.
- Be alert to sunk cost bias in the decisions and recommendations made by others. Comments like “we’ve invested so much already” and “we don’t want to waste those resources” are signals. Consider re-assigning responsibilities.
- Avoid creating a mistake-fearing culture within your organization. Set an example by admitting when you are wrong. Change course quickly without regard to the sunk costs of investments that have gone bad.
- Remember that even smart choices (taking into account what was known at the time the decision was made) can have bad outcomes (because of uncertainty). Cutting your losses does not necessarily mean that you were foolish to make the original choice.
- Try thinking of the sunk cost not as an investment that was wasted, but as an investment that (perhaps indirectly) led to valuable information indicating that a course change is needed.
- Follow the advice of Warren Buffet: “When you find yourself in a hole, the best thing you can do is stop digging.”

Supporting Evidence Bias

Supporting evidence bias is our tendency to want to confirm what we already believe and look for facts to support it. This bias not only affects where we go to collect information, but also how we interpret the evidence that we receive. We avoid asking tough questions and discount new information that might
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challenge our preconceptions.

Suppose, for example, that you are considering an investment to automate some business function. Your inclination is to call an acquaintance who has been boasting about the good results his organization obtained from doing the same. Isn’t it obvious that he will confirm your view that, "It's the right choice"? What may be behind your desire to make the call is the likelihood of receiving emotional comfort, not the likelihood of obtaining useful information.

Supporting evidence bias influences the way we listen to others. It causes us to pay too much attention to supporting evidence and too little to conflicting evidence. Psychologists believe the bias derives from two fundamental tendencies. The first is our nature to subconsciously decide what we want to do before figuring out why we want to do it. The second is our tendency to be attracted to experiences that make us feel good than experiences that make us feel uncomfortable.

Despite our inclination to look for supporting evidence, it is usually much more informative to seek contradictory evidence. Confirming evidence often fails to discriminate among possibilities. To illustrate, in one study students were given the sequence of numbers 2, 4, 6 and told to determine the rule that generated the numbers. To check hypotheses, they could choose a possible next number and ask whether that number was consistent. Most students asked whether a next number "8" would be consistent with the rule. When told it was, they expressed confidence that the rule was, "The numbers increase by 2." Actually, the rule was, "Any increasing sequence." A better test would have been to check whether a next number incompatible with the hypothesis (e.g., “7”) was consistent with the unknown rule.

Supporting evidence bias can cause us to perpetuate our pet beliefs. For example, if a manager believes people are basically untrustworthy, that manager will closely monitor their behavior. Every questionable act will increase suspicions. Meanwhile, employees will notice that their actions are being scrutinized. Closely watching employees will make it impossible to develop trust. Studies show that when people are placed in situations where authority figures expect them to cheat, more of them do, in fact, cheat. The behavior pattern reinforces itself to everyone’s detriment.

Changing what we believe takes effort. When first encountered, data that conflicts with our preconceptions is often interpreted as being the result of error, or to some other externally attributed factor. It is only after repeatedly being exposed to the conflicting information that we are willing to make the effort to change our beliefs.

Some advice for avoiding supporting evidence bias:

- Check to see whether you are examining all the evidence. Avoid the inclination to accept confirming evidence without question.
- Get in the habit of looking for counter arguments.
- In meetings, consider appointing someone to serve as devil's advocate—to argue against the prevailing point of view. If that seems too uncomfortable, at least appoint a devil’s inquisitor—someone with responsibility to ask tough questions.
- When you encounter something that conflicts with your beliefs, dig deeper. Resist the temptation to dismiss data that makes you uncomfortable.
- Be honest with yourself. Are you really gathering information to help you make a smart choice, or are you just looking to confirm what you already believe?
- Don't surround yourself with "yes men."

**Framing Bias**

The first step in making a choice is to frame the decision, but it is also where you can first go wrong. The way a problem is framed strongly influences the subsequent choices we make. People tend to accept the frame they are given; they seldom stop to reframe it in their own words. A frame that biases our reasoning causes us to make poor decisions.

Edward Russo and Paul Shoemaker [3] provide a story to illustrate the power of framing. A Jesuit and a Franciscan were seeking permission from their superiors to be allowed to smoke while they pray. The Franciscan asked whether it was acceptable for him to smoke while he prayed. His request was denied. The Franciscan asked the question a different way: “In moments of human weakness when I smoke, may I also pray?” Of course, the story describes this frame as eliciting the opposite response.

Whether outcomes are described as gains or losses influences people's choices. In one experiment, participants were asked to express their preferences among alternative programs impacting community jobs. They were told that due to a factory closing 600 jobs were about to be lost. However, if program A is adopted, 200 jobs will be saved. On the other hand, if program B is adopted, there is a 1/3 probability that 600 jobs will be saved and a 2/3 probability that none of the 600 jobs will be saved. Most people preferred program A. Another group was given a rephrasing of the choice. If program C is adopted, they were told, 400 people will lose their jobs. If program D is adopted, there is a 1/3 probability that nobody will lose their job and a 2/3 probability that 600 will lose their job. This group mainly favored program D.

![Poor framing?](image)

Similar effects occur in everyday decision making. For example, the typical New York taxi driver chooses how long to work each day based on a personal target for daily earnings. Failing to achieve the target is perceived as a loss. Thus, on slow days the driver works more hours in order to achieve the target. On busy days the driver hits the target more quickly, and quits early. However, it would be more efficient to work longer hours on fast days and knock off early on slow days. The driver would end up with more income and fewer hours worked.

Project proponents intuitively understand the advantage of focusing attention on upside potential rather than down-side risk. It sounds more positive to say that a new product launch has a "1-in-5 chance of succeeding" compared to the mathematically equivalent statement that it has a "80% chance of failing." If people are rational, they should make the same choice in every situation in which the outcomes and their probabilities are identical. It shouldn't matter whether those outcomes are described as "gains" or "losses" or as "successes" or "failures." But, the words establish different frames, and decisions often differ because of it.
Another example, described by Hammond, Keeney and Raiffa [2], involves automobile insurance laws voted on in New Jersey and Pennsylvania. Each state gave voters a new option: By accepting a limited right to sue they could lower their insurance premiums. New Jersey framed the initiative by automatically giving drivers the limited right to sue unless they specified otherwise. Pennsylvania framed it by giving drivers the full right to sue unless they specified otherwise. Both measures passed, and in both cases large majorities of drivers defaulted to the status quo. But, because of the way Pennsylvania framed the choice, drivers in that state failed to gain about $200 million in expected insurance savings.

Advice:

- Ask yourself if you are working on the real problem.
- Look for implicit assumptions or unnecessary constraints in the way that you perceive your problem.
- To promote objective reasoning, avoid framing alternatives with value-laden terminology (e.g., labeling a proposed resource allocation as "fair").
- Try posing problems in a neutral way that combines gains and losses, adopts alternative reference points, or promotes objectivity.
- Look at the problem from other perspectives. For example, reverse the context. If you are the seller, how would you see things if you were the buyer?
- Choose a frame that captures all of what's important. For example, ask, "What's the total cost of ownership?" not "What's the price?"
- Watch out for leading questions—questions or phrasing designed to create a frame intended to elicit a particular response.
- Choose a high-level perspective for framing. For example, “What is the aggregate risk of the project portfolio?” Looking only at project-by-project risk may result in a portfolio of overly conservative projects.
Estimating and Forecasting Biases

People are notoriously poor at estimating and forecasting. They interpret statistical correlation as implying cause-and-effect. They tend to naively extrapolate trends that they perceive in charts. They ignore or don’t correctly use probabilities when making choices. They draw inferences from samples that are too small or unrepresentative. They make overly optimistic forecasts that cannot be justified by available information. They routinely overestimate their abilities and underestimate the time and effort required to complete difficult tasks. Estimating and forecasting biases represent a special class of biases important to project-selection decision making.

Misestimating Likelihoods

Uncertain situations are particularly troublesome. Studies show that people make systematic errors when estimating how likely uncertain events are. As shown in Figure 2, likely outcomes (above 40%) are typically estimated to be less probable than they really are. And, outcomes that are quite unlikely are typically estimated to be more probable than they are. Furthermore, people often behave as if extremely unlikely, but still possible outcomes have no chance whatsoever of occurring.

Figure 2: People systematically over- or under-estimate probabilities.
In addition to systematically misestimating low and high probabilities, studies show that people consistently misestimate the likelihoods of events with certain characteristics. For example, availability bias refers to the tendency to overestimate the frequency of events that are easy to recall (available in memory), such as spectacular or sensational events. Recency bias relates to the tendency to attribute more salience to recent stimuli or observations, which can lead to the overestimation of the likelihood that a rare event that occurred recently will soon reoccur. Illusion of control bias refers to the tendency of people to believe they can control the probabilities of events when in fact they cannot. For example, in the game of craps, a player may throw the dice softly for low numbers and hard for high numbers. Clustering or correlation bias refers to the tendency to see patterns that don’t really exist, for example, believing that the geographic location of a supplier is related to the quality of its products.

**Overconfidence**

Overconfidence has been called, “perhaps the most robust finding in the psychology of judgment” [4]. We believe we are better at making estimates than we are. To illustrate, I’ve often repeated a well-known demonstration of what I call the "2/50 rule." Participants are asked to provide confidence intervals within which they are "98% sure" that various uncertain quantities lie. The quantities for the questions are selected from an Almanac, for example, "What's the elevation of the highest mountain in Texas?" “Give me low and high values within which you are 98% sure that the actual value falls.” When the true value is checked, up to 50% of the time it falls outside of the specified confidence intervals. If people were not overconfident, values outside their 98% confidence intervals would occur just 2% of the time.

Overconfidence is also demonstrated by the many examples of people expressing confidence about things that are subsequently proven wrong. For example, British mathematician Lord Kelvin said, “Heavier-than-air flying machines are impossible.” Thomas Watson, founding Chairman of IBM, reportedly said, "I think there is a world market for about five computers." The Titanic was the ship that couldn't sink. Likewise, surveys show that most drivers report that they are better than average, and most companies believe their brands to be of "above-average" value.

**Overoptimism**

Overoptimism describes the human tendency to believe that things will more likely turn out well than poorly. Although generally regarded as a positive trait, optimism has been blamed for a variety of problems relevant to corporate and personal decision making. This includes over-estimating the likelihood of positive events and under-estimating the likelihood of negative events. Overoptimism is cited as a reason that project managers so frequently experience project overruns, performance shortfalls, and completion delays. Economists believe the bias contributes to the creation of economic bubbles; during periods of rising prices investors are overoptimistic about their investments. It has been suggested that in many cases of corporate disclosure fraud, the offending officers and directors were not consciously lying but instead were expressing honestly-held but irrationally optimistic views of their firms' condition and prospects. A related bias is wishful thinking, a tendency to focus on outcomes that are pleasing to imagine rather than what is objectively most likely.
Halo Effect

The halo effect refers to a bias wherein a perception of one, typically overarching trait (e.g., a person is likeable) bleeds over into expectations regarding specific traits (e.g., the person is intelligent). The effect was first demonstrated by a study of how military officers rate their soldiers in various categories. The officers usually rated their men as being either good across the board or bad. In other words, there was very high correlation across all positive and negative estimations. Few people were evaluated to perform well in some areas and badly in others.

The perceptions of Hollywood stars demonstrate this bias. Because they are typically attractive and likeable, we naturally assume they are also intelligent, friendly, and display good judgment, though there is often ample evidence to the contrary. It’s as if we cannot easily separate our evaluations with respect to different criteria. The explanation may have something to do with our desire to avoid cognitive dissonance. If we valuate something as good in one category and bad in another, that makes expressing an overall evaluation more difficult.

The Halo effect has considerable influence in business, and not just for interviewing and hiring. In the automotive industry, the term “halo vehicle” refers to a limited production model with special features that is intended to help the manufacturer sell other models within the category. Similarly, Apple’s success has been attributed in part to a halo effect that Steve Jobs cast over Apple’s products. Job’s brilliant design sense made Apple’s products, and everything else about the company, including stock price, seem attractive. Conversely, investors who see Apple as being highly profitable are more likely to believe its products are high-quality and its advertising honest.

Anchoring

A bias related to overconfidence is anchoring. Initial impressions become reference points that anchor subsequent judgments. For example, if a salesperson attempts to forecast next year sales by looking at sales in the previous year, the old numbers become anchors, which the salesperson then adjusts based on other factors. The adjustment is usually insufficient. Likewise, if when estimating an uncertainty, you begin by thinking of a middle or most likely value and then consider the potential for deviations from that value, you will underestimate your uncertainty. Anchoring and adjustment leads to confidence ranges that are too narrow.

Anchors can be set through any mechanism that creates a reference point. For example, in one study, groups of consumers were shown credit card bills that either did or did not contain minimum payment requirements and asked how they would pay the debt off given their real-life finances. The payments for those who indicated they would pay over time were 70% lower for the group who saw information on minimum payments compared to those who did not. Apparently, the minimum payment works as an anchor, causing the card holder to pay a smaller amount than would have been paid.
in the absence of the anchor.

Recent events are easy to recall and often become anchors (recency bias, mentioned above). Thus, investors tend to believe that what’s happening currently to the price of a stock will continue to happen into the future (thus, anchoring contributes to stock price volatility since it prolongs up- and downswings). Knowing that recent job performance has a more pronounced affect on impressions, workers naturally work harder to demonstrate good performance in the 3 months just prior to reviews than in the previous nine months.

Vivid events can become strong anchors. When the movie "Jaws" opened at theaters across the U.S., the number of swimmers visiting California beaches dropped significantly. Sharks do inhabit the California coast, but the risk of a swimmer actually being attacked by a shark is, for most people, much less than the risk of dying in a car accident while driving to the beach. Studies show that people overestimate the likelihood of dying from dramatic, well-publicized risk events, such as botulism, tornadoes, auto accidents, homicides, and cancer, but underestimate the risks of unremarkable or less dramatic events, such as asthma, diabetes, and emphysema.

Project proponents can use anchoring to help win approval for their projects. Assuming that organizational decision makers use the common approach of considering and making decisions for each proposal in turn, proponents should seek to have their preferred projects placed on the agenda immediately following a request to approve a much larger project. The more expensive project proposal will create an anchor against which the proponent's project will seem more reasonable.

**Motivational Biases**

Motivational biases can affect estimates and forecasts whenever estimators believe that the quantities expressed may affect them personally. For example, managers may have an incentive to overstate productivity forecasts to reduce the risk that the capital dollars allocated to their business units will be reduced. More subtle biases also affect estimates provided from managers, and the effect can depend on the individual. For example, project managers who are anxious to be perceived as successful may pad cost and schedule estimates to reduce the likelihood that they fail to achieve expectations. On the other hand, project managers who want (consciously or unconsciously) to be regarded as high-performers may underestimate the required work and set unrealistic goals. Most managers are overly optimistic. When companies collect data on the financial returns from projects, they almost always find that actual returns are well-below forecasted returns.

Motivational biases can also cause people to minimize the uncertainty associated with the estimates that they provide. I have found, for example, that managers sometimes become defensive when asked to estimate the potential risks associated with a proposed project, even in environments where it is well-known that projects can fail. Perhaps they feel that admitting to downside potential would suggest deficient risk management practices or the fallibility of their project management skills. Experts likewise face disincentives to fully acknowledging uncertainty. They may think that someone in their position is expected to know, with high certainty, what is likely to happen within their domains of expertise. We do, in fact, appear to value the opinions of highly confident individuals more highly. Studies show that consultants and others who sell advice are able to charge more when they express great confidence in their opinions, even when their forecasts are more often proven wrong [5].
Poorly structured incentives, obviously, can distort decisions as well as estimates. For example, any company that rewards good outcomes rather than good decisions motivates a project manager to escalate commitments to failing project, since the slim chance of turning the project around is better from the manager’s perspective than the certainty of project failure.

**Base-Rate and Small Sample Bias**

Base-rate bias refers to the tendency people have to ignore relevant statistical data when estimating likelihoods. Small sample bias is the tendency to draw conclusions from a small sample of observations despite the fact that random variations mean that such samples have little real predictive power. For example, suppose you are planning to buy a car. You read a Consumer Report review that ranks a model highly based on uniformly positive assessments from a survey of 1,000 owners. You mention the article to a friend who recently bought this model. She swears that it is the worst car she has ever owned and that she will never buy another as long as she lives. Your friend's experience has increased the statistical sample from 1,000 to 1,001, but you're faith in the Consumer Report study has been destroyed. People are moved more by one powerful, vivid example than by a mass of statistics.

The tendency to underestimate the effort needed to complete a complex task has been attributed to base-rate bias. Instead of basing estimates mostly on the amount of time it has taken to do previous similar projects, managers typically take an "internal view" of the current project, thinking only about the tasks and scenarios leading to successful completion. This almost always leads to overly optimistic forecasts. One manager I know says he always multiplies the time his programmers say will be required to complete new software by a factor of two, because "that's what usually happens."

Variations of base-rate biases are often important in business environments, including the tendency people have to be insufficiently conservative (or "regressive") when making predictions based on events that are partially random. Investors, for example, often expect a company that has just experienced record profits to earn as much or more the next year, even if there have been no changes in products or other elements of the business that would explain the recent, better-than-anticipated performance.

**Conjunctive Event Bias**

Conjunctive events bias refers to the tendency for events that occur in conjunction with one another to seem more likely. A conjunction (a combination of two or more events occurring together) cannot be more probable than any one of its components. Yet, the stringing together of component events can create a more compelling vision that appears more likely. For example, the possibility that you may die during a vacation (due to any cause) must be more likely than the possibility that you will die on vacation as a result of a terrorist attack. Yet, one study showed that people are willing to pay more for an insurance policy that awards benefits in the event of death due to terrorism than one that awards benefits based on death due to any cause.

Conjunctive event bias plays an important role in project planning. Any complex project has the character of a conjunctive event, since each component part needs to go as planned for the whole to succeed. Even when the probability of each individual part succeeding is very likely, the overall probability of success can be low. Thus, conjunctive event bias can contribute to time and cost overruns in real projects.
Lack of Feedback

Forecasting errors are often attributed to the fact that most people don't get much opportunity to learn through feedback about the accuracy of their forecasts. We are all fairly good at estimating physical characteristics like volume, distance, and weight because we frequently make such estimates and get feedback about our accuracy. We are less experienced (and get less verification) when making forecasts for things that are more uncertain. Weather forecasters and bookmakers have opportunities and incentives to maintain records of their judgments and see when they have been inaccurate. Studies show that they do well in estimating the accuracy of their predictions.

Advice for improving forecasts and estimates includes:

- Think about the problem on your own before consulting others and getting anchored to their biases.
- Be open-minded and receptive. Seek opinions from multiple and diverse sources. Tell them as little as possible about your own ideas beforehand.
- Tell people you want "realistic" estimates. Ask about implicit assumptions.
- Consciously evaluate options using multiple criteria that reflect non-overlapping objectives and perspectives, and try not to let your overall intuitive impression influence your individual evaluations.
- Look for anchors that might be biasing estimates. Are the numbers unsubstantiated, extrapolated from history without sufficient adjustment?
- Encourage the estimation of a range of possibilities instead of just a point estimate. Ask for low and high values first (rather than for a middle or best-guess value) so as to create extreme-valued anchors that counteract the tendency toward overconfidence around a middle value.
- Look for overconfidence and overoptimism. Have the team build a case based on an outside view.
- Require project proponents to identify reasons why what they propose might fail. Conduct a "premortem: -- Imagine that in some future point in time it is apparent that the project turned out horribly, then write a history of how it went wrong and why.
- Give people who provide you with estimates knowledge of actual results as quickly as possible.
- Use network diagrams, scenario building, and similar techniques to identify and define the sequencing of component activities. A major value of such techniques is that they reduce the likelihood that necessary project activities will be overlooked (e.g., procurement and training), with the result that time and costs are underestimated.
- Routinely use logic to check estimates. As a simple example, if you have 2 months to complete a project estimated to require 2000 hours, verify that you have a sufficient number of FTE's available.
Bounded Awareness and Decision-Making Heuristics

In addition to the biases that degrade judgments, research shows that problems arise from the processes that people use to make decisions. Problems include bounded awareness and the use of flawed decision-making heuristics.

Bounded Awareness

Bounded awareness, described by Max Bazerman and Dolly Chugh [6], refers to the well-documented observation that people routinely overlook important information during the decision-making process. One cause is our tendency to become overly focused. Focus limits awareness, and important information outside the range of focus can be missed. Thus, an airplane pilot attending to status monitors and controls can overlook the presence of another airplane on the runway. Cell phones can distract drivers and contribute to car accidents.

Cognitive scientist Daniel Gilbert cites research suggesting that the human mind is inherently incapable of seeing certain things [7]. We can detect patterns in what we see, but because we are limited by the extent of our own imagination, we have a tough time imagining what is not there. Due to blind spots, we miss things, then the mind replaces what we didn't see with what it expects to experience.

George Day and Paul Schoemaker [8] observe that companies are often slow to recognize developments at the periphery of the business that ultimately turn out to be strategically important. A classic example is Motorola’s Iridium project, initiated in the 1980’s. The plan was to provide around-the-world, mobile phone service for the business community through a network of 66 low-orbiting, communication satellites. After 15 years and spending $5 billion, service was launched in 1998. However, by then the build-out of cellular phone service was well underway. Motorola’s $3,000 phones, about the size of a brick, couldn’t compete. Had the company executives been paying attention to market developments, they would likely have abandoned Iridium. Similar examples include the music industry’s failure to foresee the threat of Napster-type services, Polaroid’s bankruptcy resulting from the rapid rise of digital photography, and Wal-Mart’s surprise that social concerns would cause communities to resist the opening of new stores.

Studies show that unexpected information is particularly easy to miss. In one experiment, participants were shown a video of an exciting basketball game. There is a 5-second interval during which a person in a gorilla costume walks through the game thumping his chest. Few people recall seeing the gorilla.

Changes that occur slowly are often not recognized until it is too late. This may explain, in part, business scandals. At Enron, for example, accounting irregularities were adopted slowly. Like the boiling frog, executives may have been lulled into a sense of comfort, unaware that they were in hot water [9].
The Challenger space shuttle disaster provides an example of a situation wherein important information existed, but was not sought out. On the day of the launch, decision makers argued whether the low temperature would be a problem for the shuttle’s O-rings. Seven prior launches with some sort of O-ring failure were examined, but no pattern between failures and temperature emerged. After the fact, data were analyzed for all 24 previous launches. The expanded data indicated that the Challenger had more than a 99% chance of malfunctioning [10].

Sometimes information is known, but not acted upon. For example, the drug company Merck did not withdraw its pain relief drug Vioxx from the market until 2004. It’s been estimated that by that time the drug may have been associated with as many as 25,000 heart attacks and strokes [11]. Evidence of the drug’s risks was reported in a medical journal as early as 2000. The delay in taking action cost Merck dearly—over $200 million has been awarded in claims. Why didn’t Merck withdraw the drug sooner? The warning was available, but it appears to have been ignored.

Group dynamics hinder information sharing. Teams may discuss information, but the discussion usually conveys information that is widely known, not information that is uniquely known to a single team member. Psychologists say that this is because sharing something that others already know produces positive reinforcement in the form of the agreement of others. However, introducing into the discussion something that only you know typically doesn’t generate positive feedback—“People just sit there, and it is unclear what happens next.”

Organizational structures can institutionalize bounded awareness. Organizational silos and multiple layers of management hinder information flow. Information doesn’t get transmitted well across silos, and management layers can filter out messages management doesn’t want to hear.

Advice:

- Stay alert to peripheral threats and opportunities. Look for unknown unknowns. For example, watch for regulatory, technological, and market-oriented changes and trends and be prepared to modify your strategies.
- Instead of using the information that happens to be in the room at the time, identify what information is needed to make the decision and then get it.
- In meetings, assume everyone has unique information and ask for it. Meeting agendas should request individual reporting.
- Get outsiders’ perspectives. Outsiders may help you to see critical information that you could easily overlook when immersed in day-to-day activities.
- Break down organizational silos and other barriers to information flow.

**Decision-Making Heuristics**

Just as people use heuristics to make judgments, executives (and the rest of us) often rely on simplified reasoning to make difficult decisions. Kahneman [12] argues that the mind can be considered to have two processing components, System 1 and System 2. System 1 makes rapid intuitive decisions based on associative memory, images, and emotional reactions. System 2 monitors the output of System 1 and
overrides it when the result conflicts with logic, probability, or some other decision-making rule. The trouble is that System 2 is lazy – we must make a special effort to pay attention, and such focus consumes time and energy. Therefore, we don't always apply as much reasoning effort as we should.

According to decision theorist Herbert Simon, decision complexity coupled with limited time, laziness, and inadequate mental computational power reduce decision makers to a state of "bounded rationality." Decision-making shortcuts can save time and ease the psychological burden of decision making. However, like other judgmental biases, there are circumstances where the use of such heuristics results in bad choices.

**Selective Focus**

If a decision involves many considerations, a natural response is to simplify by focusing on a subset of what matters. However, the simplification can mislead. As illustration, an experiment was conducted on the gambling floor of a Las Vegas casino. Subjects were given chips worth 25 cents each and shown two alternative gambles:

- **Bet A**: 11/12 chance to win 12 chips, 1/12 chance to win 24 chips (a bet with a high chance of payoff)
- **Bet B**: 2/12 chance to win 79 chips, 10/12 chance to lose 5 chips (a bet with a high potential payoff)

Subjects were asked to indicate which gamble they would rather play. They were then asked to assume they owned a ticket to play each bet, and asked the lowest price for which they would sell each ticket. Subjects often chose Bet A, yet stated (87% of the time) a higher selling price for Bet B. Researchers explained the inconsistency by concluding that when asked to choose, subjects focus on the odds of winning, but when asked to set a selling price, they focus on the winning payoff [13].

Over simplifying likewise creates problems for business decisions. The "zero defects" program popular with industrial firms in the 1960's provides an example. The program was based on the idea that management should use all possible means to get a job done right the first time. However, once the program was implemented, many firms discovered that they could not live with consequences of making quality the primary goal. Quality rose, but productivity declined, production deadlines were missed, and amounts of spoiled and scraped goods increased. A high percentage of firms dropped the program.

**Intuition**

The quickest way to make decisions is by intuition. Let the subconscious mind decide and make the choice that feels right. Intuitive choices are based on emotions without deliberate reasoning. Unfortunately, our emotions can persuade us to make choices that aren't in our best interests. Failing to get positive results from a project, for example, might naturally cause some project managers to become angry. Is the manager's anger a factor in the decision to keep plugging away rather than admit failure?
An area where researchers think emotions routinely get in the way of sound choices is personal health and safety. In an experiment conducted by Andres Gershoff and Jonathan Koehler [14], people were asked to choose between cars with two different automobile air bag systems. In car one, the airbag reduced the chance of death in a crash to 2%. The second car did event better; the risk of death was 1%. However, the second car utilized a more powerful airbag, and there was a very small risk, 0.01%, that the driver would be killed by the force of the air bag deploying. Although the risk with car one was very nearly twice as high as car two, most people preferred car one. Why did the researchers think emotion was the key factor? They found that people were more likely to make the lower risk choice when they were making safety decisions for others rather than for themselves. Also, they found that participants who scored high on a personality test measuring intuitive thinking were the most likely to avoid safety products with a small potential risk of an adverse outcome associated with a malfunction.

**Reasoning by Analogy**

Reasoning by analogy means choosing a course of action based on an approach found effective for an analogous situation. For example, the business model for Toys R Us was supposedly developed based on an analogy with supermarkets; that is, let the customer see toys arranged like food down supermarket isles. Similarly, Intel reports that it moved into low-end chips to avoid U.S. Steel’s well-studied mistake in not pursuing the market in low-end concrete reinforcing bars.

Dangers arise when analogies are built on surface similarities only. For example, in the late 1990's, numerous companies, including Ford, tried copying Dell's strategy of "virtual integration" with suppliers. Dell produced build-to-order desktop computers. Ongoing declines in microprocessor prices is what made supplier integration so advantageous—Dell saved money because it could delay purchasing a processor until just before shipping the computer. The analogy fails for industries (like the autos) that aren't experiencing rapidly declining supply costs. Dell's strategy became much less effective as PC configuration standardized and fewer customers sought customized hardware.

**Reasoning by Metaphor**

Reasoning by metaphor is similar to reasoning by analogy, except that the comparison is to some easily visualized physical image. For example, when Stephen Jobs and Steve Wozniak were designing the Macintosh computer, they adopted the metaphor of making the interface perform like a desktop, where users could see folders and move them and their contents around. The familiar image is responsible for the enduring success of this ubiquitous user interface.

One of the most powerful metaphors to shape U.S. national defense policy during the Cold War was the domino theory. The metaphor portrays countries facing communism as a line of dominoes—allow one country to fall under the influence of communism and the others will also fall, one after the other. Thus, every domino was critical, and none could be allowed to topple no matter what the costs. The domino theory was used from the 1950s to 1980s by successive U.S. Presidents as an argument to prop up governments claiming to be anti-communist. Yet, many have questioned the validity of the theory. The administration of John F. Kennedy cited the domino theory as a reason for supporting the costly Vietnam war, yet when the U.S. finally left Vietnam, after some 58,000 Americans had died, communism did not then take hold in Thailand, Indonesia,
and other large Southeast Asian countries.

**Rules of Thumb**

Popular business rules of thumb include “the processing power of computer chips doubles every 18 months,” “a new business needs to have 4 consecutive quarters of profits before launching a public offering,” and “a public health risk is acceptable if the probability of fatality is less than one-chance-in-a-million.”

The problem with rules-of-thumb is that they ignore specifics and can become outdated with changing circumstances. For example, if you used a rule of thumb that a fast-food restaurant is worth 2 to 3 times its annual revenues, you might end up paying too much for a restaurant with declining sales, old equipment, and health code violations. Mortgage lenders who stuck with the old rule of thumb that borrowers can spend no more than 25% of income on mortgage payments lost out in areas of rapid price appreciation to more aggressive lenders.

**Seeking Means Rather Than Ends**

If it is difficult to determine the choice that best achieves the end goal, choosing based on some presumed means to the end can seem like a reasonable approach. Means-based decision making is especially likely if the end goal is difficult to measure. For example, organizations often fund learning initiatives based on the goal of improving the productivity of their workers. Because it is difficult to estimate the impact of a training course on people’s productivity, many corporate learning departments simply report the number of hours employees spend in the classroom. A program that manages to get 80% of employees to spend 40 hours in class isn’t necessarily providing the best learning for the company.

Seeking means rather than ends leads to decision errors when the selected means is only one characteristic or influencer of the desired end, not the cause of it. With regard to choosing projects, the end goal is to produce the greatest possible value for the organization, subject to the constraint on available resources. Because value is difficult to measure (see Part 3), a popular heuristic is to prioritize projects based on strategic alignment—projects are ranked based on how well they fit elements of stated corporate strategy. Translating strategy to action is important, however, being well-linked to an element of strategy doesn’t ensure that a project will be successful or that it will generate the most value for the organization.

**Incrementalism**

Incrementalism is an approach to decision making wherein a large change is made slowly though a series of small adjustments. The idea is to be cautious, to experiment and learn. For example, an organization might avoid a high-risk, big investment decision by making a series of small investments. The first step might be to conduct a low-cost, low-risk pilot project. If the pilot appears successful, a bolder move might then be taken. Or, an expanded pilot might come next. Home Depot, for example, reportedly uses this approach. The company’s policy is to test proposed changes to retail strategy in individual stores before making large-scale changes.

A major advantage of incrementalism is that it preserves flexibility while providing useful information. However, there are two potential problems. One is that experimenting takes time, and the window of opportunity may close before the organization is prepared to fully act. Another problem relates to sunk
cost bias. It may be hard to abandon a plan as costs accumulate because decision makers don’t want to admit that earlier investments were “wasted.”

**Over-Reliance on Experts**

Because decisions often involve complex technical considerations, experts frequently play a necessary role in decision making. Experts have credibility and command respect from others, both inside and outside the organization.

There can be problems, however, with relying on experts. Experts can easily dominate discussion and discourage constructive dissent. Over-reliance on experts can create bad choices. Experts may be biased towards solutions that rely more heavily on technology, and they may not fully understand important non-technical considerations relevant to the decision. The Bush Administration, for example, has been criticized for relying too much on experts in the Central Intelligence Agency in its decision to take down the government of Iraq.

Due to the risks associated with using decision-making heuristics, you should:

- Be careful using solutions based on analogies. Look for differences in the respective situations and ask how those differences might cause the analogy to fail.
- Don’t make a decision based on a rule-of-thumb without thinking carefully about whether the rule applies in the current situation. Have things evolved such that rule of thumb no longer makes sense?
- Think about whether your decision logic is confusing means with ends. Will what you intend to do guarantee that you get what you want? Or, are you merely choosing something that is only associated with (does not cause) the desired result?
- Watch out for the natural attractiveness of incremental solutions and the subsequent power of sunk cost bias. Is the incremental approach popular solely due to reluctance to upset the status quo? Is what will be learned that valuable, compared to the incremental costs including the costs of delay?
- Be sure to get the judgments of experts, but don’t allow them to dominate the decision-making process. Institute controls that ensure the objectivity of experts and allow others play a role and share responsibility for choices.
- Consider steering clear of the heuristic methods in favor of formal decision analysis when the stakes are high and the probability of success must be maximized.

**Decision Errors**

Figure 3 shows the 3 essential steps to benefiting from decisions: (1) recognize the opportunity to choose, (2) make a good choice, and (3) implement.
Choosing the Wrong Portfolio of Projects

Part 1: Errors and Bias in Judgment

Figure 3: Essential steps for benefiting from decisions.

Missing the opportunity to make a decision means that the "do nothing" or status quo option is chosen by default. Warren Buffet has reportedly said that he considers his worst investment failures to be missed opportunities to take action, "The things I could have done but didn't do have cost us billions of dollars" [15]. Taking advantage of an opportunity to decide doesn't, of course, ensure success. There are many reasons why a conscious business choice may be poor, including misinterpreting the problem to be solved (poor framing), not being clear about objectives, failing to identify good alternatives, and using heuristics or unaided intuition rather than reasoned logic. Finally, there is nothing to be gained from making a good choice if it is not implemented. A study by an Ohio State University researcher found that about one-third of nearly 400 business decisions studied were never implemented by the organizations involved [16].

It is often assumed that a bad decision will be evident to us after the fact. However, this is not necessarily the case. In one experiment, researchers used a card trick. They showed participants pairs of pictures of female faces and asked them to choose the face they thought more attractive. Later, they switched some of the cards and asked the participants to explain their choices. In the majority of cases where the cards were switched, participants failed to recognize the switch—they simply justified the choices they thought they had made [17].

To benefit from the power to decide, be sure to:

- Be alert to the opportunity or need to make decisions.
- Consciously frame the decision to be made.
- Be clear about decision objectives.
- Identify distinct and creative alternatives.
- Use analysis and logic to make a good choice.
- Follow through and implement what you decide.
Debiasing

The problem of bias is of critical importance, given that judgment pervades human experience and is crucial to decision making: “Should I accept this job?” “Should we develop a new product?” “For whom should I vote?” “Is the defendant guilty?” Decision-making errors, obviously, can be extremely costly at the personal, professional, and societal levels. Not surprisingly, there has been a fair amount of effort invested in looking for ways to reduce bias.

Unfortunately, there does not appear to be an easy fix. In 1982, decision scientist Baruch Fischhoff reviewed 4 straightforward strategies for reducing bias: (1) warning subjects about the potential for bias, (2) describing the likely direction of bias, (3) illustrating biases to the subject, and (4) providing extended training, feedback, coaching, and other interventions. Fischhoff concluded that the first 3 strategies yielded only limited success, and even intensive, personalized feedback and training produced only moderate, short-term improvements in decision making [18]. In the succeeding 25 years since Fischhoff's study, much additional research has been conducted, but the basic conclusion remains the same—simple methods for addressing bias have limited applicability and produce limited success. On the other hand, as described below, more involved methods, such as replacing intuitive decision making with analysis, can be effective.

Common Methods for Reducing Bias

One continuing line of research involves investigating whether biases can be reduced by encouraging subjects to put more effort into forming judgments. Asking students to “show their work,” for example, has been shown to slightly increase the chances of obtaining a correct answer (it is more helpful for pinpointing where lack of understanding may occur). In general, however, the limited success of such techniques suggests that most biases are not very sensitive to the amount of effort one applies.

Encouraging people to take an outsider’s perspective has been shown to somewhat reduce the tendency for overconfidence to bias estimates (“What do you think someone not directly involved would say?”). The idea is to reduce personal biases by removing oneself mentally from the specific situation. Some studies show that the technique can improve estimates of the time it would take to complete a task and the odds of success [19, 20].

Increasing accountability for decisions has been shown to lead to better choices [21]. Likewise, enhancing accountability for opinions that people express can help in some circumstances. For example, it has been suggested that, when obtaining critical information from someone, it may be useful to take notes (or to appear to take notes). If people believe you may quote them to others, they may be more careful in what they say. Similarly, to support project-selection decisions, it is useful to have project proponents document precisely why they believe their proposed projects should be conducted. Going on record encourages managers to be more careful in their logic, and the fear of being proved wrong helps counter over-optimism.

Note taking may encourage more thoughtful responses
Training (in biases) has been shown to help people address some biases. However, as observed by Fischhoff above, the effect is generally short lived and does not produce an overwhelming improvement in performance. One problem is that it is often hard to get people to appreciate that bias is something that affects them personally, not just others. Thus, in situations where time permits, it helps to demonstrate biases. For example, if you are obtaining judgments from a group of individuals and are concerned about overconfidence bias, don’t just tell them about the 2/50 rule (described above). Instead, run them through an exercise that demonstrates that the rule applies to them.

Not surprisingly, improving cause-effect understanding of the relevant situation and processes has been shown to improve the quality of estimates and decisions. For example, studies show that when people are encouraged to look for common principles underlying seemingly unrelated tasks they are able to better create solutions for different tasks that rely on the same underlying principles [22].

There is evidence that groups reach better decisions when alternatives are evaluated simultaneously as opposed to having each alternative evaluated sequentially and potentially rejected. The presumed explanation is that people initially react emotionally when considering an alternative; they think mostly about how it will affect them personally. If alternatives are evaluated simultaneously side-by-side, group members are less susceptible to this reaction [23].

**Strategies for Reducing Specific Biases**

The usual strategy for reducing a specific bias is to address the mental processing error that is believed to produce that bias. For example, in one study, researchers assumed that *hindsight bias*, the tendency to exaggerate the extent to which one could have anticipated a particular outcome, results from the difficulty people have in appreciating the limited information available at the time and the restricted inferences that could be made from that information. By providing evidence that argued against the actual outcome, they found that their subjects could be made more resistant to the bias [24]. Similarly, it has been hypothesized that people’s tendency to over-claim credit for a group accomplishment is due in part to the tendency to be more aware of one’s own efforts. Researchers showed that when people are asked to estimate not only their own contributions but also those of others, they attribute less credit to themselves [25].

Figure 4 (derived from Wilson and Brekke [26]) illustrates a view for how judgmental biases are created and suggests a general strategy for reducing biases. According to the figure, the first step is to create awareness of the flawed mental processes involved. The subject must be motivated to correct the bias, and understand the direction and magnitude of the errors produced. Finally, the bias must be removed or countered. The technique used to mitigate the bias of concern is often the application of a countering bias, for example, countering overconfidence by encouraging subjects to describe (and therefore anchor on) extreme possibilities. Many of the recommendations provided earlier in this section under “Advice” are based on this logic.
Decision Aids

Hundreds of decision aids have been developed or recommended to reduce the distortions in decisions caused by errors and biases. I developed the list of sample aids below in the context of a chapter I prepared for a book on aids for environmental decisions [27]. (Note that many entries in the table represent a category or type of aid rather than a specific aid.) As indicated, there are at least 5 categories of aids: (1) checklists for promoting a quality decision process, (2) thinking aids intended mainly to improve perspective or create insights, (3) models and optimization methods for recommending choices, (4) aids for promoting group consensus, and (5) voting methods. As an example of the first category, Figure 5 is a checklist aid for scoring the decision-making process relative to the components of a quality decision-making process.
**Sample Decision Aids**

<table>
<thead>
<tr>
<th><strong>Checklists</strong></th>
<th><strong>Optimization methods</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinking aids</td>
<td>Linear programming</td>
</tr>
<tr>
<td>• DeBono’s six hats</td>
<td>Integer programming</td>
</tr>
<tr>
<td>• SWOT analysis</td>
<td>Quadratic programming</td>
</tr>
<tr>
<td>• Theory of constraints</td>
<td>Dynamic programming</td>
</tr>
<tr>
<td><strong>Models and analysis</strong></td>
<td><strong>Probabilistic optimization methods</strong></td>
</tr>
<tr>
<td>• Comparison methods</td>
<td>Decision trees</td>
</tr>
<tr>
<td>- PMI (listing pluses, minuses and “interesting”)</td>
<td>Stochastic programming</td>
</tr>
<tr>
<td>- Paired comparison methods</td>
<td>Fuzzy logic</td>
</tr>
<tr>
<td>• Weighted comparison methods</td>
<td><strong>Game theory methods</strong></td>
</tr>
<tr>
<td>- Analytic hierarchy process</td>
<td>• Zero-sum games</td>
</tr>
<tr>
<td>- ELECTRA</td>
<td>• N-person games</td>
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<tr>
<td>- Force field analysis</td>
<td>• Cooperative games</td>
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<tr>
<td>- Grid analysis</td>
<td>• Non-cooperative games</td>
</tr>
<tr>
<td>- Goal programming</td>
<td><strong>Group facilitation methods</strong></td>
</tr>
<tr>
<td>- Kepner-Tregoe methods</td>
<td>• Delphi technique</td>
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<tr>
<td>- Multi-attribute utility analysis</td>
<td>• Nominal group method</td>
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<tr>
<td>- PROMETHEE</td>
<td><strong>Voting methods</strong></td>
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<tr>
<td>- SMART (simple multi-attribute rating technique</td>
<td>• Approval voting</td>
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<tr>
<td>• Cost-benefit analysis</td>
<td>• Borda count</td>
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<tr>
<td>• Decision analysis</td>
<td>• Copeland’s method</td>
</tr>
<tr>
<td>• Social choice theory</td>
<td>• Plurality voting</td>
</tr>
<tr>
<td>• Expert systems</td>
<td>• Plurality with run-off elections</td>
</tr>
</tbody>
</table>

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**Figure 5:** Checklist diagram for evaluating deficiencies in the decision-making process [28].
Notice that a common characteristic among decision aids is that they add structure to the decision making process, forcing decision makers to rely less on intuition and emotion and more on deliberate thinking. Models and analysis, in my opinion, represent the most effective way to address errors and biases in decision making. Essentially, the concept is to replace flawed intuitive reasoning with a formal, analytical process. Much evidence has accumulated indicating the effectiveness of models and analysis. For example, in situations where past data are available on the inputs and results of a decision making process, models can be created using regression analysis. Such models are being used to help graduate schools to decide which students to admit, clinical psychologists to diagnose neuroses and psychoses, and credit card companies to decide whether to accept loan applications. For a very wide range of subject areas, researchers have found that such models produce better and more reliable decisions than those made by people, including the experts who made the original decisions from which the models were derived [29].

Even very simple models have been shown to improve estimates and, therefore, encourage better decisions. Ask people to estimate how tall an eight-story building is, and you will likely get very poor estimates. But, if they envision each floor as being about 50% higher than a tall person, say 10 feet, and then multiply by the number of stories, the result of 80 feet is fairly accurate. A model doesn't need to be very precise or even require very accurate inputs. To illustrate this, in training classes I've asked managers to estimate quantities about which they know very little, for example, “How many chicken eggs are produced in the U.S. each year?” The estimates are not very accurate. Then, attendees break into teams to create a simple model the output of which is the number in question. For example, a team might calculate annual egg production as the number of people in the country times the average number of eggs consumed per week times the number of weeks in the year. Invariably, the teams produce much more accurate estimates using their models.

Another argument for using models comes from research that shows that experts appear to be less subject to biases when addressing issues that are entirely within their areas of expertise. Models break the problem of evaluating alternatives down into individual pieces such that different experts with specialized knowledge can be selected to focus on each piece. Thus, models dissect a complex problem in a way that makes the required judgments less likely to be biased.

**A Strategy for Decision Making**

Approaches to making good decisions differ greatly in terms of the amount of time and effort required. Intuitive decisions can be fast, automatic and effortless, while analysis is slower and requires considerably more effort. Figure 6 illustrates that the appropriate approach to decision making depends on the significance of the decision, the challenges involved, and the time available for analysis. It is useful to develop a quiver of decision-making strategies, and to select the approach that makes most sense for the given circumstance.
Figure 6: The appropriate decision aid and decision-making approach depends on the nature of the decision.

The best protection from bias comes from training, using formal techniques for obtaining important judgments, utilizing well-founded decision models and analysis, and instituting rigorous decision processes that document the judgments and assumptions upon which choices are based. The subsequent parts of this paper describe such a process specific to decision-making for project portfolio management. As stated by Ken Keyes, "To be successful in the business world we need to check our bright ideas against the territory. Our enthusiasm must be restrained long enough for us to analyze our ideas critically" [30].
Choosing the Wrong Portfolio of Projects

Part 1: Errors and Bias in Judgment

References for Part 1


11. Goldacre, B. Bad Science, Quacks, Hacks, and Big Pharma Flacks, Faber and Faber, 2011.


Failure to See the Forest for the Trees

Most organizations put ample effort into making individual projects successful, but not enough effort into making the entire portfolio of selected projects as successful as it could be. The fault does not lie with project managers. Most project managers are highly motivated. If their projects are funded, they do their best to deliver on time and within budget. However, just because an organization has a portfolio of mostly on-time and on-budget projects does not mean that it has the best possible project portfolio, or that it is effectively allocating resources among the projects that it is doing.

The problem is that project managers are focused on their individual projects, not on the overall project portfolio. Few project managers, for example, suggest terminating their projects if things are going badly. Likewise, the typical project manager does not look for opportunities to redirect his or her resources toward the projects of other project managers who would benefit from them more.

Senior executives, unlike project managers, do not judge success on a project-by-project basis. What does (or should) matter to them is the aggregate cost, value, and risk of the project portfolio. Likewise, the chief executive's concerns are mainly about achieving the over-arching objectives of the organization, for example, maximizing return for investors. Whether or not individual projects succeed is, generally, of secondary importance.

Although it should be obvious that it is the performance of the project portfolio as a whole that really matters, many organizations do not manage the aggregate cost, value and risk of their total project portfolio. Either no one has responsibility for managing the project portfolio, or the efforts to do so are not as effective as they could be. Project managers tend to the individual "trees," but no one is caring for the "forest." Failure to see the forest for the trees is the second reason organizations choose the wrong projects.
Problems with Project-by-Project Decision Making

Failure to manage at the level of the project portfolio creates several predictable and closely-related problems, including portfolios with too many projects, inadequate and poorly disseminated project-related information, poor project choices, inconsistent and inappropriate priorities, and misallocated resources.

The Downward Spiral that Produces Poor Project Portfolios

If project selection decisions are not made at the portfolio level, by default the project portfolio is the end result of individual project choices made one at a time with little regard for the impact that one project choice has on the next. The typical result, illustrated in Figure 7, is a dysfunctional feedback loop, or downward spiral, that produces too many projects, inadequate project information, inability to kill failing projects, and too many low-value projects.

![Figure 7: The downward spiral resulting in poor project portfolios.](image)

Too Many Projects

The reasons that organizations generally undertake too many projects have to do with the way projects are generated and the way that project go/no-go decisions are made. In many organizations, projects are...
initiated by functional executives and others with little regard for whether resources are available to do the work. Most organizations have many pressing needs, so there are many opportunities for spending project resources. Because there is little or no collaboration or coordination among project requesters, many more projects are proposed than there are resources to conduct them. Then, regardless of whether tools are used to formally evaluate project proposals, the basis for a "go" in project-by-project decision-making is necessarily whether or not the proposed project is judged to achieve some hurdle or threshold of acceptability. Project proponents learn to persuasively argue that acceptability criteria are met. Thus, projects look good, especially in their early stages, so many projects pass the hurdle. Later, when people are assigned to projects, it becomes apparent that they are committed for more than 100% of their time.

A typical hurdle for large projects imposed by many organizations is calculation of financial net present value (NPV). If the NPV is positive, the hurdle is achieved and the project is deemed a “go.” For most projects, it is easy for project proponents to make assumptions that ensure that the project NPV will be positive. Thus, few projects get screened out based on financial criteria.

**Poor Project Performance**

Resource managers feel they have no choice but to undertake approved projects, so resources are multitasked in the attempt to satisfy all. The more people multitask, the less efficient they become. Too many projects mean that resources are spread too thinly. Project managers compete for necessary resources. Key resources become overloaded and progress slows. People take shortcuts to complete projects because they have too many things to work on and can’t take the time to do what they need to do right. Stress levels go up, morale suffers, and the team concept starts to break down. Quality of execution drops and project schedules slip. More time is spent negotiating for resources, adjusting project costs and reviewing budgets than on finishing projects.

**Inadequate Project Information**

Surveys routinely report that management complains about insufficient information for decision-making. For example, R. G. Cooper reports that a study of product development projects at 300 firms "revealed major weaknesses in the front-end of projects: weak preliminary market assessments, barely adequate technical assessments, dismal market studies and marketing inputs, and deficient business analyses" [1]. The information that is available is typically scattered across different people, departments, and business units, making it difficult to aggregate knowledge sufficiently to execute informed decisions about where to invest scarce resources, how to prioritize initiatives and balance project demands. Doing project work competes with time spent developing project data, so too many projects means that insufficient time is devoted to developing better project data.

**Failure to Kill Projects**

Poor information gives management an insufficient basis for making tough decisions. No one wants to be the one to kill a questionable project, "It's like drowning puppies!" As a result, failing projects don't get terminated soon enough. Failure to kill failing projects compounds the problem. Nothing sucks up resources and exhausts project teams more than trying to save a failing project. Resources are spread even more thinly.

**Bias toward Small, Low-Risk, Short-Duration Projects**

Not only does inadequate information lead to an inability to kill projects, it also tends to create a bias
toward small, low-value, low-risk, short-duration projects (e.g., extensions, modification, and updates). High-value/high-risk projects aren't viewed as feasible (given the constraint on resources). Even if bigger, riskier projects are proposed, management may be unwilling to take the risk due to the lack of adequate information. When a large project does get started, available resources get sucked into the big one, often leaving other projects high and dry.

Other Symptoms of the Downward Spiral
Not sure if your organization is suffering from the downward spiral? Other symptoms include:

- No standardized way to document or compare projects.
- Politics plays a bigger role in project selection than business value.
- Projects experience excessive delays due to not enough resources.
- Project status can change frequently, from “active” to “on hold” to “top priority” and back again.
- Departments and business units compete, rather than cooperate, when staffing and funding projects.
- Executives have no clear view of the project portfolio and its business motivations.
- There’s no obvious link between the portfolio and executive-level concerns, such as organizational mission, market share, or stock price.
- Project managers frequently find it difficult to find enough of the right people to adequately staff their projects.
- There’s no real evidence that completed projects contribute much to the business.

Inconsistent and Inappropriate Priorities
A related problem is that the failure to establish organizational priorities causes inefficiencies in the day-to-day allocation of people’s time. Consider the following example from an article by the Product Development Institute, Inc. [2]:

Imagine that you are a member of a project team in a typical organization. Like most project team members, you are working on several projects simultaneously. You are under pressure from all your project managers to make faster progress. Suppose you finish a milestone on an important project ahead of schedule. Do you use the opportunity to get an early start on your next task on this project?

More likely, you turn your attention to one of your other projects. Your day-to-day priorities are based on your desire to minimize the pressures you feel from your various project managers. Although the organization may benefit more from your taking the opportunity to put your important project ahead of schedule, that project is unlikely to obtain the benefits of your early finish.

The point being made by the authors is that work is always prioritized. It is only a question of who does it and how. In the absence of established priorities, people use their own prioritization methods. One common prioritization method is first in first out (FIFO). "Whatever task shows up in my in-box first, I do first." Another common prioritization method is the "squeaky wheel." Whoever complains to me the loudest gets the work done first.” Others include doing first the work for the manager that you like the
best, has the most interesting projects, or writes your performance reviews. None of these methods is likely to result consistently in the best allocation of resources for the organization.

Prioritization is a task for the organization's leadership. Unless management makes the effort to prioritize projects, the allocation of project resources will be left to individual project managers, and they will prioritize based on what seems best from their personal perspectives, not the perspective of the organization as a whole. The results will be unpredictable, and not likely in the best interests of the organization.

**Misallocated Resources**

Too often, an organization’s approach to allocating a limited budget is something like this. Individual business units identify projects, compute their funding needs, and submit budget requests. When the total funding requirement is computed, executives decide that spending must be reduced. Rather than consider carefully how the shortfall should be distributed across organizational units, the decision is made to cut each unit's request by the same percentage. Taking the same cut from each unit's project portfolio is regarded to be "fair."

"Fair Share Allocations" Aren’t Fair

The problem with this approach is that all organizational units do not have the same ability to absorb cuts in spending. A 10% reduction in project funding may result in more than or less than a 10% reduction in the value delivered from the project. In some extreme cases, such as that illustrated in Figure 8, eliminating a fraction of funding can eliminate all of the value of the project!

![Figure 8: Cutting the budget may eliminate all of the value of a project portfolio.](image)
Combine Projects into a Portfolio

Solving the problems caused by project-by-project decision-making requires shifting focus from the project to the project portfolio. Unlike project management, which is concerned with applying knowledge, techniques and tools to help ensure that individual projects succeed, project portfolio management (PPM) is concerned with applying knowledge, techniques and tools to ensure that the entire collection of related projects is as successful as it can be. With PPM, the quality of information and understanding is improved, and the common decision-making errors that reduce the value derived from projects are avoided.

Building an effective project prioritization and portfolio management capability takes effort, but it doesn’t have to be an expensive or daunting task. Also, it can be done without software. In fact, as described by Johana Rothman in her book, *Manage Your Project Portfolio* [3], you don’t even need to wait until your organization adopts PPM to start. Because PPM can be practiced at any level, you can begin experiencing the benefits of PPM by managing as a portfolio the work at your personal level of influence within the organization. The enabling step is to place information about projects into a portfolio.

Create a Portfolio of Projects

Rothman suggests you begin PPM by finding out what people are working on, now and what they expect to be working on over the next few weeks or months, or for whatever time horizon commitments are reasonably knowable. The scope should include business initiatives, discretionary spending, and work viewed as mandatory, including compliance, and contractual obligations. Focus on project work; that is, unique undertakings that have specified deliverables and projected start and finish dates. Determine who, what and when—who is doing or will be doing the work, what the project is, and over what time period the work is expected to proceed.

The work being undertaken will include large and small projects that result in specified deliverables that by themselves would be useful. There may also be chunks of work that are needed to obtain some larger deliverable, but that have limited utility by themselves. Any piece of work that has a deliverable that by itself is valuable, whether large or small, should be regarded for the purposes of the portfolio as a project. If there are collections or series of small pieces of work that individually don't add up to significant value, but do together create value, combine them into a single project.

Once you've identified all ongoing and planned work, organize the work into a portfolio. The most common format for displaying the project portfolio is a matrix where projects are listed in rows with information about the projects arrayed in columns. Figure 9 provides an example.
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The project portfolio shows the project inventory. It provides a birds-eye view of work requested and performed. Having this information in one spot and tagged with key information helps you, the team, and executives to better understand and assess what the organization is doing.

Explore Resource Demands and Scheduling

If project timing and resource demands are added to the matrix, the portfolio display becomes a useful device for supporting sourcing and scheduling decisions. Sourcing defines how we secure and allocate resources, while scheduling determines when we allocate those resources based on needs and planned availability.

The usual approach is to add columns to the project matrix indicating units of time moving left to right. The columns could represent weeks and/or months, whatever is most useful depending on the duration of projects and nature of the staffing commitments. You can do this in an Excel spreadsheet (see the next section), or you can start without any sort of formal tool. For example, Rothman [3] recommends creating the initial project schedule as a group exercise, by drawing a template on a whiteboard and having participants write project information onto sticky notes. Projects that extend over multiple time periods can have a sticky for each period. Participants then post the stickies onto the appropriate locations on the template, producing a result something like that shown in Figure 10. As illustrated, you can arrange the projects such that any unstaffed projects are placed at the bottom of the list.

This view of the portfolio shows the pipeline of upcoming project work. This sample portfolio provides weekly detail for the next four weeks and a high-level perspective for another three months. It identifies unstaffed projects, making it easy to spot projects that are at risk for being delayed due to constraints on people's time.
Figures 9 and 10 represent only one of a number of possible ways of displaying projects, people, and timing. They show a high-level view of what people are working on and expect to be working on while highlighting those projects that still require staffing. Such high-level views are most useful for conveying a big-picture understanding. They help participants understand how work will progress and aid management of the interaction among projects. A big picture view helps reveal patterns and provides a sense of the project collection as a whole. Another common way of displaying the portfolio shows the details about who is doing what and when. Figure 11 provides a low-level view of a portfolio, where you can see who is assigned to which projects and, in this case, the phases of the projects.

<table>
<thead>
<tr>
<th>Staff</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
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</thead>
<tbody>
<tr>
<td>Adam</td>
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<td>Project 1</td>
<td>Project 1</td>
<td>Project 1</td>
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<td>Project 1</td>
<td>Project 3</td>
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<tr>
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<tr>
<td>Howard</td>
<td>Project 2</td>
<td>Project 3</td>
<td>Project 1</td>
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<td>Project 1</td>
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<tr>
<td>Unstaffed</td>
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<tr>
<td></td>
<td>Unstaffed</td>
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</tbody>
</table>

**Figure 11: A more detailed view of the project portfolio.**

Low-level portfolio views can be useful for highlighting work that cannot start until specific people finish what they are already doing. A portfolio view that shows all the demands on project personnel helps staff from becoming overcommitted. A manager may want someone to work on another activity, but if the portfolio makes it clear that the individual is already 100% committed, it is readily apparent that work on other projects will slow if the person takes on another demand.

A high-level view of your portfolio gives you a feel for all the projects you have underway, while a low-level view shows you more of the details but less of the overall pattern. Both views can be useful for tweaking sourcing and scheduling choices. The delta between total available resources and what’s in use at any given time represents available resources to assign to new initiatives. Non-discretionary projects can be staffed first, with resources for discretionary projects scheduled during the timeframes in which they occur and necessary resources become available. If resources are insufficient to serve every project, projects may be prioritized to ensure the best use of limited resources.

**Prioritize**

As explained previously, it is common for organizations to propose and then try to do too many projects. Available resources are insufficient to allow all desired projects to be undertaken, and it may not be possible to start important new projects unless some existing projects are killed or placed on hold. What really makes the project portfolio useful is that it can serve as an aid for making project decisions. The key, as suggested in Figure 12, is to prioritize projects in the portfolio.
New projects will compete for resources with existing, ongoing projects, so you should work with a portfolio that includes ongoing projects together with newly proposed projects. The complete project portfolio should consist of ongoing staffed projects, projects that have been approved but not yet staffed, and new projects that are under consideration but not yet approved. Even if you don’t want to consider killing or slowing ongoing work, you need to account for all project demands on organizational resources.

The Correct Metric for Prioritizing Projects

The goal is to select the portfolio of projects that collectively will contribute the most value. As explained in the paper on mathematical theory, this means that you should rank projects based on value created per unit of cost ("bang-for-the-buck"), with cost being the total cost of the project (all costs yet to be paid), including labor costs. Many authors advise you to rank projects based on project value, but as shown in Figure 13 this is not correct.

The figure compares the value delivered by projects as a function of total cost depending on whether...
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Projects are prioritized based on the ratio of value to cost or based on project value alone. Each rectangle represents a candidate project. The width of the project rectangle represents project cost and the height indicates project value. When projects are ordered by the ratio of value to cost, higher portfolio value is obtained for the available budget. As shown, ranking projects by value alone results in a large loss in total portfolio value, especially if the costs of projects differ significantly and the budget is highly constrained. It may at first seem counterintuitive that a low-value project could rank higher than a high-value project. Smaller projects will naturally tend to generate less-impressive, less-valuable outcomes, but if a project consumes a relatively small portion of the scarce resources, it could contribute sufficient bang-for-the-buck to warrant including it in the list of approved projects. Thus, the correct consideration for ranking projects is the worth of the project outcomes relative to the project costs. Ranking based on estimates of project value alone gives the wrong result.

Manually Ranking Projects

Part 3 of this paper explains how to construct models and tools for prioritizing projects. If you don't have such a tool, you can prioritize projects manually using forced ranking—force the projects into a strict priority order based on your judgments regarding value delivered for the cost spent. Can this be done? Since estimating the value of a project relative to its costs is difficult, you may question whether projects could be ranked in this way. In my experience, though, people can and do successfully rank projects. Think about projects with which you are familiar. Regardless of your level within your organization, you will almost certainly be able to separate the best projects from the mediocre. If you are a first-level manager, you have intimate knowledge of your projects and the deliverables they will create. So, you'll have some idea of the relative importance of your projects. If you are a middle manager, you'll have a feel for how the projects being conducted by your project managers relate to the various business needs being addressed and the relative importance and urgency of those needs. If you're a senior manager, you'll have an understanding of your organization's strategic direction and have a sense for how the various projects contribute to organizational success. Thus, so long as you have understanding of projects and what they are intended to accomplish, you have a basis for judging project value. You can then compare your assessment of the value of each project with its cost, and reach a judgment regarding the effectiveness with which it utilizes scarce resources. By such reasoning you can assign rough priorities to projects and, thereby, rank them.

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<thead>
<tr>
<th>Rank</th>
<th>Project</th>
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<td>1</td>
<td>Project 1</td>
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<td>Project 6</td>
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<td>7</td>
<td>Project 7</td>
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<td>8</td>
<td>Project 8</td>
</tr>
</tbody>
</table>

Figure 13: A prioritized project portfolio.

Publish your priority list so that everyone will know in what order you will choose to allocate resources. The prioritized list lets everyone know what work is viewed most useful. They'll see what's in the pipeline and understand the tradeoffs that would be necessary to accommodate changes in priorities.
Involve Stakeholders Project Ranking

Even though you could specify priorities on your own, without discussion, it is far better to get help from others. Ranking projects is best done as a group exercise. If you do it yourself, you'll likely be wrong about something. If you collaborate with your peers, you'll benefit from their knowledge about the projects, and it will be easier to make choices from the perspective of what's good for the business as a whole. Even if you are the CEO, you should involve your senior management. This has the added advantage of allowing others to understand why you rank projects the way you do.

If there are lots of projects, group ranking can take a while. One way to speed a collaborative ranking is to bring in a draft ranking that you’ve developed on your own. It will allow other people to see what you are thinking and why you think certain projects deliver more bang-for-the-buck than others. Just don't become too attached to your draft; engage others in discussing it and change it if what they think makes sense to you. The first time you try group ranking, it will be difficult for people to reach consensus, but as participants learn to work together, and project work is moving through the pipeline toward completion, the process will become quicker and easier. For additional methods to facilitate the judgmental ranking of projects, see the subsection below entitled Improve the Prioritization Process. Using models to prioritize projects is discussed in Part 3 of this paper.

Decide whether to Accept, Kill, Postpone, or Revamp Projects

The proper logic for choosing projects based on a priority list, assuming the projects are defined in such a way that they are independent of one another and that they are ranked based on the ratio of value to cost, is to select them from top down until you've exhausted the available project budget. Projects higher on the list make the cut, lower projects don't. In practice, though, deciding what to do with each project is more complicated than that. There may be multiple constraints limiting the projects that you can do at any one time (e.g., people with skill sets that are in high demand). Thus, you will likely need to stagger high-priority projects or adjust schedules to accommodate resource availability. Also, urgency (How soon do you need the project deliverables?) may be relevant for determining the sequence for doing projects.

Despite these complexities, having a correctly prioritized project list will aid the decision of what actions to take with regard to each project in the portfolio. Typically, you’ll want to staff the highest priority projects first. If certain resource constraints mean that some projects making the budget cut can’t be undertaken, consideration can be given to acquiring additional resources through hiring, consulting organizations, or staff augmentation firms. If easing critical resource constraints isn’t feasible, then you made need to postpone some lower-priority, resource intensive, and less urgent projects into the next budget cycle. In that case, and if the budget can accommodate them, a few less resource-intensive projects close to the budget line might then be conducted in place of the projects that because of specific resource constraints need to be delayed.

The available options for each project are, in general, accept, kill, postpone, and revamp. If the project is ranked very high in priority, the appropriate decision is likely to be to commit to doing it. Committing to a project means a commitment to funding the project and assigning the necessary people plus whatever other resources (e.g., space, capital equipment, desks, etc) are required for the effort. A commitment to a project cannot be a partial commitment. If you can't fully commit the necessary people
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and money, you are guaranteeing the project will not provide the value assumed when it was assigned high priority. On the other hand, a commitment to a project is not a permanent guarantee the resources will continue to be provided through the entire life of the project. If the need for the project goes away, the project turns out to be more expensive to conduct, or it becomes apparent that the anticipated value simply won't materialize, a previously approved, ongoing project may need to be terminated at some point in the future.

Another option is to kill the project. Killing a proposed project means rejecting the project proposal. A project that has already started may need to be killed if the current, best estimate of the value of the completed project is small compared to the remaining, yet-to-be-paid, project costs. Before terminating an ongoing project, consideration should be given to whether project risks and/or cost escalation can be managed by reorganizing, creating work-arounds, or redoing the work. Note that killing an ongoing project can produce project termination costs (e.g., contract termination costs), so avoiding those costs is a component of the value of continuing the project. Thus, the priority assigned to completing an ongoing project is the current, best estimate of the value of the project deliverables, plus any avoided project termination costs, divided by the remaining project costs. Since the remaining costs decline as the project progresses, the ratio of value to cost for projects generally increases as the project proceeds. For this reason, unless there is a major decline in estimated project value or escalation in project costs, the priority for completing ongoing projects increases over time.

A third option for the project is to place it on hold. A project may be attractive, yet not have sufficient priority to make the cutoff. Such projects can be deferred for consideration again in a later decision cycle. If in that later cycle budget constraints become less severe or if competing projects are less attractive, the deferred project may then be initiated.

A last option is to transform or revamp the project. If a project isn't assigned sufficient priority to make the cut, it may be possible to change the project in such a way as to decrease its cost while increasing its delivered value. Transforming a project can be as small as clearing up misconceptions about the project, or as drastic as replacing the project team or changing the project design and goals. When projects are prioritized based on comparing project value with cost, project proponents know what they must do if they are to obtain positive funding decisions.

**The Portfolio is a Means, Not an End**

A project portfolio is not a static document. As you discover additional work, add it to the portfolio. As things change, reprioritize the projects. A prioritized portfolio helps people to see which projects to spend time on now and what they might do in the future. Most important, people know where not to spend their time. It can serve as a visual tool that helps you negotiate which projects to do when. The managers use the portfolio to make sure the organization is working on what's most important—work that will create the most value for the organization.

Looking at projects from the perspective of the portfolio makes projects look less like discrete efforts and more like a connected suite. Information and understanding is improved. Interdependencies among projects can be noted. New requirements can be evaluated against current commitments. Portfolio analysis allows investigating questions like, "How are resources for Project A impacted if Project B is delayed?" The portfolio extends the focus beyond individual project management and highlights objectives and goals that serve value creation.
As shown here, even if you don't have buy-in or support from above, you can benefit from creating and managing a project portfolio for the work that you or your team is responsible for doing. It will provide support and stability your team needs. Your portfolio will help you answer your managers' questions more quickly and completely—even if they don't yet buy into the notion of a portfolio. It will help you make the best decisions in your sphere of influence.

The next section describes how software magnifies the benefits of project portfolio management.
Software Helps You Manage the Project Portfolio

As illustrated in the previous section, you can practice project portfolio management (PPM) without software. However, software makes it much easier and much more rewarding. If you have lots of projects, using software is a practical necessity.

PPM software puts project data into an electronic database (Figure 14). This allows the information to be easily accessible, facilitates keeping data up to date, and enables analysis and reporting. Tabular and graphical displays can be provided, and the tool makes it easy to aggregate project data, drill down from high-level to low-level portfolio views, and create summary reports. With software, you have the ability to define, organize, and align information in such a way that you can view different types of information simultaneously, at different levels of detail.

Using software allows you to more easily create project portfolios and to populate them with much more project data. You can establish various project classification schemes and create multiple, interconnected project portfolios.

**Single or Multiple Portfolios**

A single project portfolio can be constructed containing all of your organization's ongoing and proposed projects. Alternatively, multiple project inventories can be created representing project portfolios for different departments, programs, or business units. The choice of one portfolio versus many depends on the size of your organization, its structure, and the nature and interrelationships among the projects that are being conducted. Having just one, single, all-encompassing portfolio elevates portfolio management to the enterprise level, which provides improved visibility and opportunities for optimization. However, working with a single, very large portfolio is procedurally more complex and tends to constrain...
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executives accustomed to exercising discretion over project selection. It might not, therefore, make sense to try to force a centralized project portfolio on an organization accustomed to decentralized management and decision making.

Similar projects that address similar problems and use common resources should be grouped so as to leverage the understanding and expertise needed for portfolio management. In particular, interrelated projects should be placed in common portfolios. Portfolios of highly interrelated projects, typically referred to as “programs”, represent groups of projects that must be selected and managed in a coordinated way in order to achieve success. Figure 15 illustrates the relationships that may exist among portfolios in a large organization.

![Diagram of portfolio relationships](image)

**Figure 15: Sample relationships among portfolios, programs, and projects.**

Portfolio groupings should be organized so as to be as independent of one another as possible. Decisions about what projects to conduct within one portfolio should not depend in a significant way on the projects that are conducted within any other portfolio. The decision of how to allocate resources among the various project portfolios can then be made at a higher level, based on estimates of the how the value of each portfolio depends on the resources made available to it.

**Project Classification Schemes**

Since it is useful to be able to monitor and control the mix of various types of projects within the project portfolio, a project classification scheme should be established. Projects can be classified in many different ways. Examples include: size; type/purpose (e.g., maintenance, growth, productivity, innovation); geographic location; skills or technologies required; sponsor, client or market served; asset class addressed (e.g. infrastructure, IT); and stage of the project life cycle (e.g., R&D, commercialization). Multiple schemes can be used so that each project is classified in several different
ways. No one approach is best for every organization. The key is to choose a classification scheme that will yield information and understanding most useful for decision making. Knowing the various categories to which a project belongs helps to characterize that project and enables the construction of charts indicating how spending is distributed (e.g., Figure 16).

![Sample chart for investment mix based on project classification.](image)

**Figure 16:** Sample chart for investment mix based on project classification.

**Project Inventory**

There are many software tools that can help you construct and manage your project portfolio, including Excel. The information entered into your portfolio database depends on your selected project classification scheme and the project attributes important for assessing priorities. Useful data includes the project name, type, responsible business unit, a brief project description; internal and external costs; and estimated time to completion. In order to support project prioritization, the recorded information should also include some level of business justification and value assessment. What, exactly, is the need that is being addressed? What benefits are expected from doing the work? Also, risks associated with successfully completing the project or securing the benefits should be identified. Finally, in situations where change is rapid, the time urgency of the project should be indicated. If the project is delayed, what will the consequences be?
Figure 17: Sample information included in a project database (electric utility example).

If project information is standardized, a template can be provided for submitting project proposals. The template may be a paper form, but electronic forms are easier. Using a standardized project information template encourages complete proposals and more consistent proposal evaluations.

Data on proposed project staffing, phasing, and resource requirements may likewise be entered. Depending on project types and duration, requirements may be specified by month, week, or even day by day. Most projects require contributions from staff with specialized skill sets. In accordance with the theory of constraints, capability to implement the project portfolio will be limited by one or more specific resource constraints. Accounting for resource requirements by skill set requires establishing a taxonomy of organizational skills, and each project must then estimate work needs by skill set. In the example of Figure 18, (an IT project to enhance a website) project phasing is represented by a Gantt chart. The numbers entered under the various months are the estimated percentage time requirements for the indicated task duration from staff with the indicated skill sets (e.g., business analyst, program manager, HTML programmer, etc.).
Most organizations using software for PPM opt to collect additional project data. Including more fields for characterizing projects results in more opportunities for sorting the data in various ways. However, there is little point to forcing project managers to generate information that won't be used. The purpose of collecting data is to support decision making, so the system should not be burdened by a requirement to collect data not useful for this purpose. For practical reasons, the task of generating data for the portfolio should be kept as simple as possible consistent with the goal of providing the information needed to support portfolio management.

**Data Roll Up**

A concise summary of proposed and ongoing work can be generated by having the software display a high-level view of the project data.

**Figure 18: Sample project timing and resource inputs (IT example).**

**Figure 19: Sample project inventory (pharma example).**
A major benefit of such displays is the transparency that comes with a single, comprehensive view. Anyone with access to the software can see the entire collection. Awareness increases, relationships are identified, and portfolio direction can be better managed. The ability to sort and filter the data facilitates understanding about the focus and emphasis of proposed work.

To help identify resource constraints and aid scheduling, project phasing and resource requirements can be displayed on a common timeline. The example assumes that projects follow the generic lifecycle phases of define, design, develop, test, deploy and post-launch.

If resource availability numbers are entered into the software, demand can be compared with supply. The results (Figure 21) aid the phasing of projects to meet resource availability constraints.

**Figure 20:** Sample project inventory timing and resource needs (IT example).

**Figure 21:** Portfolio resource demand-supply comparison.

**Benefits of Establishing an Electronic Project Portfolio**

Using software, even simple spreadsheets, expands and enhances the benefits of working with project portfolios. Whereas previously various individuals could see a piece of the picture, no one could easily access the complete view of ongoing and upcoming work. Software facilitates sensible sorting, adding, and
removing projects from the collection informed by an all-inclusive perspective. Displays can quickly be created that allow project teams and managers to better understand the work and to make the necessary tradeoffs for deciding which work to start and finish now, what to do later, and what to do never. Summary measures conveying data related to cost, risk, and benefit can be instantly computed and used to create graphics and comparative analyses that allow decision-making teams to collaborate on project-selection decisions. Individuals throughout the organization with understanding of the business can review project data and assessments to provide "reality checks." Processes can be instituted to allow users to correct errors and misunderstandings, thereby ensuring that project information reflects current and best-available understanding.

Larger organizations, in particular, typically find that creating their first portfolio of ongoing and proposed projects is revelational, "I didn't know we had so many things going on, no wonder we can't get anything done!" Counting projects produces instant value. If you schedule 130% of your human resources to projects, for example, you can be assured that some things won't be done. Reducing the number of projects eases the strain on common resources, giving remaining projects the resources they need and eliminating time spent by managers in negotiations over people and other resources. The initial project inventory often uncovers significant duplications and mismatches. For example, CIO Magazine [4] reports that when Schlumberger first grouped IT projects, they found that 80% overlapped. Duplicate efforts should be eliminated, obviously, and similar projects combined into a single project. Schlumberger reportedly saved $3 million just by eliminating project redundancies.

Adopting PPM creates a shift away from one-off, ad hoc approaches to project management. The portfolio establishes practices based on visibility, standardization, and measurement as a means for process improvement. By emphasizing the goal of creating the greatest value for the resources available, the portfolio promotes a culture of lean operation, with goals like eliminating waste as you work your way through projects; discovering and eliminating roadblocks to throughput; evening the workload for people and teams; optimizing for the entire organization, not just one piece of it; obtaining desired results in the shortest time and for the least cost; and avoiding the creation of an inventory of partially completed work.

Figure 22 summarizes these and other benefits of working with a project portfolio.
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- Supports optimization of resource allocation.
- Standardizes metrics/methods for project forecasting and tracking.
- Improves communication throughout the organization.
- Promotes accountability for project investments.
- Forces executives toward consensus on policy-level issues.

- Fewer redundant and overlapping projects.
- Promotes objectivity for project selection and prioritization.
- Faster access to project data.
- Consistent tracking of project time and expenditures.
- Facilitates inter-project coordination.

- Helps level the playing field.
- Facilitates communicating needs, rationale for projects.
- Promotes leveraging reusable project information.
- Clarifies project objectives and goals.
- Forces executives/sponsors to accept responsibility for some project risks.

Figure 22: Some benefits of creating a project portfolio.
Establish a Portfolio Management Office

A project portfolio management (PPM) office is an organizational unit whose function is to manage the organization's project portfolio, which includes prioritizing projects, allocating resources to projects, and, on a regular basis, identifying which projects to initiate, reprioritize, or terminate. A key focus is ensuring that the overall collection of projects creates the greatest possible value by maximally supporting the objectives of the enterprise. In addition, the PPM office collects and distributes data for reviewing, assessing, and managing individual projects to ensure that they are meeting their expected contributions to the portfolio. As illustrated in Figure 23, portfolio management provides the necessary link between project management and enterprise management.

![Figure 23: Portfolio management links project and enterprise management.](image)

An organization that establishes a PPM office demonstrates commitment to achieving PPM maturity. The practical indications of such maturity include the establishment of clearly defined PPM duties, the consistent application of PPM processes, and success in each and every aspect of project and portfolio management.

**Participants, Authorities, and Responsibilities**

The first step for establishing a PPM function is to decide who will participate as active managers of the project portfolio. A project portfolio manager, typically a senior manager, should be appointed with accountability for the success of the entire project portfolio. This is not always an easy position to fill. The successful PPM leader has a rare combination of talents: solid people skills plus technical acumen; detail oriented but comfortable dealing in abstract concepts; experienced but able to think outside the box. The table below lists important skills of the portfolio manager.
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Important skills and capabilities for the portfolio manager

- Good understanding of the organization’s vision, mission, and strategy.
- Understanding of project and program management, including ability to assess project health based on high-level reporting documents.
- Leadership skills, including communication, presentation, and team building.
- Broad understanding of the business, including markets, customer base, partners, and applicable regulations.
- Able to interact effectively with senior executives.
- Good analytic skills, with understanding of the basic concepts and techniques for project valuation and risk assessment.
- Understanding of process development, change management, and continuous learning.

Ideally, the portfolio manager should be given an estimate of the total funding to be made available, but it should then be up to the portfolio manager to determine how to allocate the funds within that cost constraint. It should be possible for the portfolio manager to suspend at any time further commitment of investment dollars due to cost increases, failure to make anticipated progress, changing economic climates, or shifts in business conditions. At the very least, the portfolio manager should have responsibility for recommending resource allocations for final approval by a committee of senior executives. In either case, senior executives should be enlisted to serve as a steering committee responsible for providing and updating (e.g., in response to changing business objectives) the value judgments and policy decisions needed to guide PPM

A PPM team should support the portfolio manager. The team, oftentimes, includes department heads from sub-organizations that generate requests for projects, provide project resources, and/or use project deliverables. The team should have responsibility for verifying cost, value, and risk estimates provided in support of project proposals and requests for resources. This team is then responsible for evaluating project proposals, accepting or rejecting proposals, accelerating and decelerating projects, allocating resources, and otherwise continuously managing the portfolio over time. One member of the team should be designated as the primary contact person for each project manager.

**Adopt a Successful Portfolio Management Process**

The successful PPM process includes four major components (Figure 24). First, a structured process is used to acquire key information about all projects and to organize project data into one or more project portfolios. Second, consistent and objective methods are employed to analyze projects and compare their risks and benefits. Third, resource demands are compared with capacity so that the subset of projects that make best use of available resources can be selected. The final component consists of tracking portfolio performance for ongoing assessment and adjustment. The management of these components is the responsibility of the PPM team.
Figure 24: Components of project portfolio management.

More detailed responsibilities of the team are illustrated in Figure 25. On a regular basis tied to the planning and budgeting cycle (i.e. annually, biannually, or quarterly), the portfolio team reviews all projects that are seeking funding, including ongoing projects and new project concepts. Projects are screened to determine which proposals require formal evaluation and prioritization. Projects exempted from formal evaluation include obvious "non-starters," very small projects, and projects that are more appropriately funded from other budgets. Ongoing projects and “mandated” projects may or may not be exempted (see below).

Figure 25: Typical portfolio management cycle.
Project managers with projects that pass the initial screening are authorized to use resources to complete additional analysis necessary to provide the data required for entry into project proposal templates. In some instances, the necessary resources can be non-trivial. For example, a proposed construction project may require some minimal level of engineering analysis to determine feasibility, set project scope, provide cost estimates and estimate project effectiveness at addressing needs. Alternatively, a feasibility study for a large project might itself be a project that competes for funding within the project prioritization process.

Be aware that, in most cases, PPM forces an increase in the effort spent on analyzing project opportunities. The extra effort is justified by the need for better information to support decision making. To be as efficient as possible, screening systems may be used to select a different level of data requirements and analysis for different types or sizes of projects.

**Mandated and Ongoing Projects**

Although some organizations exempt mandated and ongoing projects from formal evaluation, my recommendation is that both types of projects should be routinely evaluated just as "discretionary projects" are evaluated. In some organizations, "mandated" projects consume almost the entire budget. Very strict criteria should be established for labeling projects mandatory to ensure that they are defined with minimum possible scope and cost. For example, a mandated project might be defined as the minimum effort needed to avoid non-compliance in the budget year with a documented regulatory or legal requirement. Add-ons that go beyond what is strictly required should be defined as discretionary projects (alternative versions of a mandated project may be defined, with the requirement that at least one version be selected—see below). Formally evaluating mandated projects promotes consistency, provides useful information, and helps the organization ensure that all of the benefits of mandated projects are, in fact, identified and achieved.

Evaluating ongoing projects for continued funding is useful to ensure that struggling or obsolete projects do not prevent funds from being available to meet more-pressing needs. Where possible, large, long-duration initiatives should be reframed as a series of smaller projects. For example, in the case of a software project, it may be better to make incremental funding decisions to develop improved versions rather than deciding whether to create one big Version 1.0 that does everything. The concept is to identify small "chunks" of work of the minimum size and scope necessary to generate some measurable benefit.

Although project managers often object to re-evaluating their previously-approved projects, requiring ongoing projects to be re-evaluated is not unfair or overly burdensome to the managers of those projects. Not as much effort is required to re-evaluate an ongoing project because template inputs need only to be updated rather than generated "from scratch." Estimates tend to get less uncertain as a project proceeds in its life cycle, and providing up-to-date inputs allows portfolio information to be kept current.

Also, as noted earlier, ongoing projects have an advantage in the competition. Independent projects should be prioritized based on the ratio of value-to-cost; the relevant costs are the remaining costs needed to obtain the anticipated project benefits, exclusive of costs already spent. Thus, the denominator used in the ranking metric decreases as the project proceeds. Furthermore, when evaluating on-going projects, the costs of terminating a project must be considered. Avoiding contract termination costs, staff reassignment costs, etc., are legitimate benefits of continuing the project. Thus, achieving the
required bang-for-the-buck usually isn't difficult for ongoing projects. If an ongoing project is eliminated, the decision should be regarded by all as an instance of successful resource reallocation, not as a personal failure on the part of a project manager.

**Gate Reviews**

Note that the evaluation of on-going projects for the purposes of project prioritization is not meant to replace other project progress evaluations. A large, multi-stage project may need to be evaluated at specified phases or "gates" to ensure that it is on track to meeting its milestones and deliverables (Figure 26). For example, a complicated project might include development of an initial concept, a feasibility study, a design phase, an engineering phase, and so forth. At each stage, managers may decide to revamp the project. Project gate reviews involve in-depth evaluations based on real-time information, but they are typically made in relative isolation to the decisions made on other projects.

![Figure 26: Project gate reviews must be coordinated with project portfolio management.](image)

With PPM, gate reviews can be used to trigger project re-prioritizations (prior to the next portfolio review) or even an immediate project cancellation. More typically, though, gate reviews result in modifications to project tasks. At least at the early stage of PPM adoption, it is usually best to allow portfolio management activities and gate reviews to proceed more or less independently. As PPM maturity advances, more sophisticated methods can be used to manage task-level detail as part of the PPM process.

**Prioritizing Projects between Major Reviews**

As demonstrated by the example noted above, projects may sometimes have to be evaluated between the major budgeting cycles. This is true even in the absence of formal gate reviews. For example, a project may need to be re-evaluated if there is a major, adverse change in the project scope, a risk event occurs, an assumption is found not to hold, or there is a realization after completing a portion of the work that earlier cost or schedule estimates were overly optimistic. Also, urgent new projects may need to be evaluated between planning periods. Evaluations between major reviews involve comparing such projects against the most-recently established project priorities. A contingency fund may need to be established to accommodate projects that may be added outside the normal budget cycle. Even so, if additional new work is authorized, it may mean some work previously authorized will need to be slowed, canceled, or delayed.
Multiple Project Versions
A very useful practice is to require multiple versions of proposals for large projects. For example, if a project exceeds some specified size, some organizations will require project proponents to submit enhanced, decremented, and minimum-cost versions of the project, in addition to a base-case or preferred version. By providing project alternatives, organizations can avoid "all-or-nothing" choices for important, but resource-demanding projects. Also, as shown in Part 5 of this paper, providing alternative project versions for projects can result in a significant increase in the value generated from the optimized project portfolio.

Proposal Evaluation and Process Management
Based on formal evaluations, projects are prioritized and "go," "no-go," “kill,” and "hold" recommendations are made with the goal of creating a value-maximizing project portfolio. Project recommendations are reviewed by the executive committee and project funding for approved projects is authorized. Projects are phased based on critical paths to fit people and other resource constraints, with the most urgent projects starting first. Projects designated as "hold" may be resubmitted later (oftentimes project managers redesign such projects with the goal of increasing benefits and decreasing costs).

The PPM office monitors the status of on-going projects to ensure that projects stay on track to achieve the anticipated benefits that motivate their being included in the selected project portfolio. Once the project is completed, the products (assets, services, etc.) delivered or enhanced by the project should be similarly monitored and evaluated to ensure that the forecasted benefits are realized. The performance of activities that utilize project outputs is typically beyond the responsibility of the project portfolio manager. However, it is important for responsible managers to provide the project portfolio manager with feedback on the extent to which actual benefits are in fact achieved. Without such feedback on actual performance, there is no real accountability.

In addition, the PPM office should:

- Ensure consistent and accurate progress reporting on the costs and other critical resources consumed by projects.
- Define and develop the detailed, continuous process by which projects are evaluated, prioritized, selected, and managed.
- Enforce a collaborative effort that enables senior executives (the steering committee) to reach agreement on portfolio goals and objectives.
- Provide coaching and training to project managers to help them to understand project evaluation criteria and to enable them to efficiently generate inputs for the project template.
- Communicate to project proponents and other stakeholders which projects are approved and project priorities.
- Provide stakeholders with timely assessments of portfolio progress, with early identification and correction of portfolio-level issues that may impact performance.
- Adjudicate resource conflicts between projects.
- Maintain visibility of key project information across the enterprise.
- Ensure that the project portfolio remains in tune with changing business objectives and strategy.
- Identify lessons-learned and continually refine the PPM process.
Improve the Prioritization Process

The most important step in project portfolio management (PPM) is choosing which projects to fund, and making the right project choices. Managers and their organizations are facing increasing internal and external pressures to cut costs while being more effective at meeting constantly changing demands from customers within narrowing windows of opportunity. In many organizations, projects are repeatedly added, changed, and removed in response to heightened business activity. The backlog of "must do" projects requires resources that often exceed what the organization can provide. Given today's level of business competition, making the wrong project choices and ineffectively using limited resources can threaten the very survival of the business.

In order to continually make the best use of limited organization resources, the PPM office must determine which projects to initiate, which on-going projects to continue to fund, which projects to revamp, and which projects to kill. As illustrated in Figure 27, the PPM office must make project decisions so as to optimally manage the "project pipeline."

Since organizations rarely have sufficient resources to conduct all available projects, projects must be prioritized. In the absence of formal models for prioritizing projects, managers can use forced ranking. As explained previously, forced ranking means that managers get together and "force" each project into a strict priority ordering (or into a number of priority groups). Projects are then added to the portfolio in rank order until the business runs out of resources. Below that point, projects are put on hold or killed outright. Considerations that apply at the portfolio level, such as project synergies and portfolio risk, may be used as modifiers to the project-by-project ranking. Needless to say, forced ranking, as well as the final choice of which projects to conduct, are difficult decisions. In the absence of a more formal approach, bias, mental errors, and politics can play a major role in project selection.

As I argued previously, individuals knowledgeable about the projects under consideration have the
ability to separate high priority from low priority projects. I've seen ample evidence that a PPM team, using the right processes, can reliably produce a rough priority ranking of projects. Forced ranking becomes more difficult and time consuming, however, if there are:

- **Many project proposals.** If there are more than twenty or so requests, decision makers may not be sufficiently informed about the projects or their underlying needs to make consistent choices. This is especially true when proposals come from different departments or jurisdictions.

- **Project complexities.** If projects are technologically complex, require "apples versus oranges comparisons," or involve difficult-to-judge considerations (such as risks or critical timing factors), most experienced individuals will be hard pressed to provide reliable priorities without reference to formal criteria.

- **Multiple decision makers.** The more people involved in priority setting, the less likely it is that they will agree without first agreeing on the objectives, principles, and criteria to guide project prioritization.

- **A need to justify project choices.** There may be stakeholders not involved in setting priorities, including those who provide project proposals, who require an explanation for the funding choices that are made. If decision makers arrive at their choices intuitively, they may have trouble explaining priorities when questioned or challenged.

In nearly all instances, but especially so under the above complications, a key challenge for the PPM team is reaching agreement over how projects should rank. Paired comparisons and point scoring are two techniques that can help groups rank projects.

**Using Paired Comparisons to Facilitate Forced Project Ranking**

If there aren't too many projects, you can use paired comparison to conduct group rankings. Place the name of each project on a paper sticky or index card. Hold up two of the cards and ask, "Which of these two projects is higher priority?" The essential step is to make sure participants base their priority judgments on the correct consideration. According to the relevant mathematical theory, projects need to be prioritized based on the ratio of project value to total project cost (assuming the projects are independent of one another). People often incorrectly prioritize based on a judgment of relative value, which, as I illustrated back in Figure 12, results in the wrong project choices. Thus, if the resource requirements of the projects differ significantly, you may need to remind participants that higher priority should be assigned to the project with the higher ratio of value-to-cost, which may not be the project with higher value.

Initially, many people will be reluctant to express their opinions. In the interest of time, you'll need to encourage quick responses. Don't waste time with discussion if everyone is in agreement. Make sure there is someone knowledgeable about each project to explain and answer questions in case others are unclear about exactly what the project will do. If people disagree on priorities, encourage opponents to express their arguments, but call for a vote where necessary to avoid getting stuck.

Once the first two projects have been compared, put the higher priority project at the top of the list and the other one below it. Now take a third project card and compare it in turn to each of the two previously considered projects to determine where it should be placed. Continue until the group has compared all of the projects to each other, at which point you've ranked the entire list.
Using Point Scoring to Facilitate Forced Project Ranking

A problem with paired comparisons is that it will take a lot of time if there are more than a few projects and/or people don't quickly agree on the pairwise comparisons. A quicker option is to have each participant assign points to each project, such that the number of points assigned indicates the individual's view of the project's priority. If there are a large number of projects, you may need to partition them into groups of similar projects with no more than ten or so in each group. Each person allocates points to the projects to indicate his or her estimate of the project's value relative to its cost. The only requirement is that no project may be allocated more than 100 points (highest possible priority). The process works best if people are required to assign a unique number of points to each project (no ties). You can pick one project to include in multiple groups to serve as a benchmark (a participant must assign the same number of points to the benchmark each time). Finally, to obtain the group ranking, add up the number of points assigned to each project by the participants.

When people drastically disagree on the number of points, have them discuss what's different about their views. Relevant questions include: How will this project affect the business? Will it make a significant difference in our ability to achieve our mission? What, exactly, are the benefits that will be produced? Will it make a temporary or lasting difference? Is there much risk that the project will fail to achieve its goals? How urgent is the project, would its effectiveness decline significantly if we delay it? Again, be sure that people base priority estimates on the ratio of value to cost.

Be Careful Using Scoring Models

An important characteristic of the above methods is that they can be applied consistent with the rule that each participant's estimate of priority be based on judgments of project value relative to project cost, which is necessary if the goal is to choose projects that create the greatest total value. In contrast, some organizations use scoring rules that do not result in projects being ranked according to this necessary logic. A common approach is to define criteria relevant to judging projects and specifying a simple scoring scale for each criterion. For example, with regard to a given criterion, 1 = poor, 2 = OK, and 3 = good. The scores are tabulated and used to obtain a total score for each project. A total score above a certain level is judged a "must do." Alternatively, projects might be ranked or grouped into priority categories based on their total scores. Other common variations include grouping projects into priority categories, for example, projects that address safety issues or projects related to regulatory requirements, designated "priority one."

In addition to the logical flaw associated with failure to prioritize based on the ratio of value to cost, scoring methods of this sort typically produce practical problems. Frequently, too many projects get high scores and/or are labeled must do's. If some types of projects, such as safety projects, are designated as critical, project proponents may place their projects in the critical categories even though the connection is small or indirect at best. For example, a project might be labeled a safety project because there is some influence on safety, even though it is clear that the very small decrease in the number or severity of accidents that would result from the project could not justify the cost.

Assigning a number to something doesn't necessarily make for a more accurate method of measurement. If scores are subjectively assigned to measures without clear criteria, different people will assign wildly different scores for the same project, and the same person may assign different scores on different occasions. Regardless, middle scores are common for most projects, especially when numerous scoring
criteria are used. High scores on some criteria cancel out low scores on others. Furthermore, most scoring models aren't sufficiently precise to trust small differences in total scores.

In any case, ranking projects by project scores will be incorrect unless those scores measure the ratio of project value to project cost. Most scoring systems don't claim to measure value. Even when they do, they often fail to scale results to project cost and, therefore, don't come close to indicating "bang for the buck."

**Improve Project Data**

Even the best project prioritization process will be worthless without adequate project data. "A micrometer won't help you measure a cloud." Thus, one way to improve the prioritization process is to improve the quality of available project information.

The first step to getting better data is to make sure that information requirements are well-defined. If project proponents are clear about what information is needed to enable their proposals to be considered, they are much more likely to supply that information. Thus, the templates for collecting data on project proposals must be complete and precise.

Second, there should be a culture and expectation that rigor is required to generate project proposals. Estimates and forecasts should be backed by reason and analysis. Project proponents need to do their homework before the project gets proposed up the management chain.

Third, the organization should be prepared to allocate increased resources to project planning. Skill, experience, and true cross-functional collaboration are often needed to generate solid project proposals. Inevitably, increasing the effort devoted to preparing project proposals detracts from the resources available for actually doing projects. However, as previously asserted, the tradeoff in improved decision making will likely be worth it.

Note that a lack of adequate systems for collecting detailed, quantitative project data should not rule out attempts to implement PPM. In my experience, project evaluation systems based mostly on data generated subjectively through "best professional judgment" can perform surprisingly well, so long as those providing the judgments are knowledgeable and unbiased. Invariably, PPM acts as a "forcing function" that causes the organization to improve its ability to collect and document important business data.

**Estimate Cost, Value and Risk**

Using the right criterion to prioritize projects, the ratio of project value to project cost, is critical. Thus, you can support the prioritization process by providing a value and cost estimate for each project. Estimating project cost (not to mention project value) can be difficult. Be sure to use full cost accounting. When evaluating proposed expenditures, some organizations make the error of detailing only non-routine costs, such as one-time, "build" costs, external contractor and consulting costs, and technology costs. As mentioned earlier, project costs include not just the funding request, but also any funding provided from other sources plus the opportunity cost of using equipment, personnel, raw material and any other "non-costed" resources that will be employed by the project. Also, all future costs necessary to obtain project benefits, including future operating and maintenance costs, should be identified, estimated, and included in the calculation. A project to install a $100,000 building security
system, for example, will likely produce future costs associated with the necessary labor to operate and maintain the system.

Some companies still do not track costs at the project level, relying instead on the general ledger system to impute approximate project costs. Tracking project costs is essential to encourage accurate estimating and provide budget data needed to make, monitor, and update project decisions. The foundation for effective PPM includes a finance system that tracks labor costs using fully burdened labor cost rates for roles and individual resources.

Estimating value is even more difficult than estimating costs. Establishing a PPM office, creating a database of available projects, and instituting forced ranking of projects helps, but the project portfolio won't be optimized without the ability to estimate project value. Thus, the key to reaping the full benefit of PPM is implementing a formal, organized, and logical method for measuring project value.

Establishing logic for quantifying project value, in my opinion, is not only critical to obtaining accurate and consistent project priorities, it is critical to justifying the role of the PPM office within the governance system for the enterprise. PPM is fundamentally different from project management with regard to the governance structure. Project management, primarily concerned with achieving project deliverables, is largely a tactical function. Delegating the function without providing formal systems to ensure compliance with executive preferences raises no issues. However, PPM is focused on making project decisions intended to achieve the fundamental and strategic objectives of the organization. To justify the delegation of the portfolio management function to a team other than the organization's most senior executives requires a formal prioritization process that makes explicit what would otherwise be the implicit preferences of senior management. Thus, PPM demands that systems be in place to help managers measure the value of projects consistent with the organization's fundamental objectives and strategy as established by senior executives. This leads to the most interesting part of the discussion—developing the metrics and models for measuring project and portfolio value. The next part of this paper explains how this may be accomplished.
References for Part 2


Lack of the Right Metrics

The metrics that an organization uses for evaluating projects have a big impact not only on the projects that get chosen but also on the projects that get proposed. "Tell me how you will measure me, and I will tell you how I will behave" [1]. Even if the metrics aren't used to create incentives, managers interpret them as indicating what the organization regards as important. Lack of the right metrics is the third reason organizations choose the wrong projects.

Metrics = Incentives
Defining Project Value

The metrics for evaluating projects must support the goal of project portfolio management, which is to maximize the total value to be derived from the project portfolio. Thus, we need metrics for measuring project value. How do you measure project value? More fundamentally, how do you define value? These questions are more perplexing than you may think.

A Definition of Value

People have been arguing about the definition of value for centuries. The relevant concept of value for our purposes is termed the “utilitarian concept of value:” The value of a project is a measure of the degree to which that project enables the organization to achieve its objectives. This view of value was first articulated in the fourth century BC by Aristotle—the value of something is not an intrinsic property of that thing, but rather is determined by its usefulness to those that want it.

Organizations conduct projects because they believe that the outcomes or consequences of the projects will be useful. The more useful the project outcomes, the more valuable the project will be. The project consequences that are desired depend, of course, on the organization's fundamental objectives. Suppose, for example, that an organization's fundamental objective is to create value for its shareholders (more discussion of shareholder value is provided below). Suppose further that the organization is considering a hypothetical project that provides only one consequence: an immediate, one-time cash flow to the company of one million dollars (to be more precise, suppose that the magnitude of the cash flow from the project is such that, after all tax and accounting considerations are addressed, increases the net worth of the company by $1 million). Under these specified assumptions, it would seem reasonable to conclude that the value of that project is $1 million.

An extension to this line of reasoning, which applies regardless of what the organization’s objectives might be, is to argue that the value of a project is the worth, to the organization, of obtaining the consequences of the project. Thus, project value might be defined as an amount of money that is equally as desirable as the project, including consideration of risk. (In other words, if project consequences are uncertain, project value could be defined as the amount of cash deemed equally desirable as the gamble over those uncertain project consequences.) In the portfolio context, this may be interpreted as an amount of cash that would make executives indifferent between (a) the portfolio with the project and (b) the portfolio without the project but with that amount of incremental cash.

In the literature on valuation, the above definition of project value is termed the project’s “selling indifference price” (also called the “breakeven selling price”). A close relative is the “buying indifference price” (or “breakeven buying price”), which argues that the value of a project is the amount of cash that would make executives indifferent between (a) the portfolio without the project and (b) the portfolio with the project plus a debt equal to that amount of cash.
In my experience, most people find it intuitive that the value of something is what you are (just) willing to give up for it. For this reason, my working definition for project value is the maximum amount of organization wealth executives would be willing to trade away to obtain the (uncertain) project outcomes. This is a variation of the buying indifference price—it is a buying price because it is an amount the organization would pay to buy the project consequences, and it is an indifference price because it is the price point such that the organization is indifferent between declining the project versus paying the price and obtaining the project consequences.

Although conceptually intuitive, determining the buying indifference price for a project gets more complicated when you consider that paying a buying price means not investing in something else. Buying A means that you cannot buy B, so the true cost of buying A is not getting the most valuable B that you could have bought. Thus, the most an organization would be willing to pay to obtain the consequences of a project should be less if doing the project means foregoing other, very good investments than when it would mean foregoing only marginal investments.

Also, if the organization were to pay a buying price, the budget available for investing would change, so the opportunity cost of incremental investments may change. In the portfolio context, as indicated above, a project indifference price is an incremental value, determined relative to other projects in the portfolio. If the projects are interdependent, the indifference price will depend on those other projects. Thus, if the indifference price for a project is determined based on it being the first project in the portfolio (or if its value is determined in isolation to other projects), we’d likely get a different value than if it is being added to other portfolio projects. In general, therefore, project indifference prices depend on the order in which the projects are added to the portfolio.

Fortunately, these complexities need not be of
much concern for our context. Organizations obtain capital from a variety of sources and spend that capital on numerous different investments. As a practical matter, it is impossible to know when candidate projects are being considered which other investments would be foregone if there are incremental reductions to available investment capital and what the opportunity costs would be. More importantly, our concern is identifying the set of projects that can be conducted within a specified budget that will produce the greatest value. Project prioritization, with projects ranked based on the ratio of value to cost (as shown in the paper on Mathematical Theory) will identify the value-maximizing portfolio provided projects are defined to be independent of one another. If the projects are independent, they can be considered one-by-one, in isolation to one another, and with value being relative to the case where the project is not done. So long as we assume the same opportunity cost when establishing the worth of the possible consequences of the different projects, the project ranking will be correct. Thus, the subtleties for setting indifference prices are unlikely to pose significant problems for project prioritization, and defining project value as the worth of project consequences is workable for our purposes.

Note that the value of a project, defined in this way and under these assumptions, does not depend on its cost. (The decision of whether to conduct a project, does, of course, depend on cost. In particular, you would never want to conduct a project whose cost was greater than its value.) An exception to the rule that project value does not depend on project cost would be a case where paying for a project impacts the organization's ability to benefit from the project or from other projects. An extreme example would be a project anticipated to produce great project outcomes, but whose cost would bankrupt the company. In such cases, the value of projects would logically be the value of the project consequences taking into account any effects of having to pay for the project. Since we are concerned with organizations that conduct numerous projects, each of which consumes only a portion of the budget, we can typically safely ignore such effects.

Our preferred definition of project value has a critically important property—it maps to organizational project preferences. Suppose there are two projects requiring the same cost and resources, and only one can be added to the project portfolio. The organization will prefer Project A to Project B if and only if our measure of project value is higher for Project A than it is for Project B (because an organization would be willing to pay more for the consequences of Project A than for Project B if and only if it prefers Project A’s consequences). Many common approaches to project prioritization don’t use a project evaluation measure with this essential property (e.g., strategic alignment). Unless project value is defined in a way that maps to the true preferences of the organization, that measure cannot correctly prioritize projects. Our definition of project value is a true measure of the relative attractiveness to the organization of its project alternatives, and that measure can be compared with project costs to determine the projects that are worth doing and their priorities.
Project value is the worth to the organization of the (possibly uncertain) consequences of doing the project—in other words, it is the maximum price the organization would pay to obtain project consequences:

Project A is preferred to Project B if an only if:

\[ \text{Value[Project A]} > \text{Value[Project B]} \]

OK, assuming we accept that the worth to the organization of the project consequences is a reasonable definition of project value, how do we determine how much an organization should be willing to pay to obtain those consequences? Before addressing that question we need to consider more carefully why organizations conduct projects.

**Projects Determine the Evolution of the Business**

The business of an organization is always evolving, and the projects that the organization chooses affect that evolution. For example, a new technology might become available that would allow the organization to reduce its costs. If a project is conducted to install the technology, the organization would incur lower operating costs than it would have if it had chosen not to do the project.

It is also true that the projects that an organization chooses not to do affect the evolution of the business. For most organizations, standing still means falling behind. There are many reasons for this, including increasing competition, changing customer preferences, and the aging of organizational assets. Thus, to take one example, if the organization chooses not to do projects that maintain or replace aging assets, the service provided by those assets will decline.

Figure 18 illustrates a useful way to think about project value. At the point in time when an organization is considering a new project, it is really facing a choice between two alternative future states. If the project is conducted, that project will, presumably, transform the business to some more desirable state. If the project is not conducted, some other, presumably less-desirable, state will result.
Choosing the Wrong Portfolio of Projects

Part 3: Lack of the Right Metrics

Figure 18: Project choices determine the future state of the business.

The perspective of Figure 18 provides a basis for computing project value. The value of a project is the difference between the values of the two potential future states of the business:

\[
\text{Project value} = \text{Value with the project} - \text{Value without the project} \quad \text{(Equation 1)}
\]

Some Observations Regarding Project Value

Based on Equation 1, we can conclude some important things about project value.

- To estimate project value, it is necessary to consider what would happen if the project is not conducted as well as what would happen if the project is conducted. Many project scoring systems ignore the implications of not doing projects, which causes some types of projects to be grossly undervalued.

- The same project can have different values to different organizations. For the purposes of estimating project value, therefore, it is not sufficient to consider just the characteristics of the project itself. It is also necessary to consider characteristics of the business that determine how useful that project will be to that business.

- The value of a project can change depending on what other projects are conducted. Because of synergies and economies of scale, for example, the costs and benefits of a project can change based on the other projects that are also conducted. If such dependencies exist, optimizing the project portfolio requires estimating the value of conducting different groupings of the interdependent projects.
For the purpose of identifying metrics for measuring project value, the most important implication of Equation 1 is this: Project value is the contribution that the project makes to the total value achieved by the organization. Because project value is the difference between the values that the organization attains in two alternative states, the methods for estimating project value are essentially the same as the methods for estimating organizational value. This is good news, since management scientists have devoted considerable effort to determining how best to measure the value created by organizations. We can use the concepts and methods that they have devised to help us to quantify project value.

**Inadequacy of Financial Metrics**

So, how can you measure the value created by an organization? Interestingly, most businesses get it wrong.

Most businesses use financial metrics computed from cash flows to measure value, for example, return on investment (ROI), return on assets (ROA), internal rate of return (IRR), net present value (NPV), pay-back period, etc. Using these metrics to evaluate candidate projects requires forecasting the cash flows that would be produced by the project. Some impacts on cash flow may be relative easy to forecast, in particular, the costs to conduct the project and any direct impacts the project will have on the firm’s future costs and revenues. However, it is difficult to translate many project consequences into impacts on cash flow. For example, how would a project designed to collect better information about customer preferences impact future cash flows? From a practical standpoint, cash flow analysis will not capture many project impacts.

Thus, at best, financial metrics provide only a partial representation of what is important to a business. According to a study by Research Technology Management, companies that rely mostly on financial metrics obtain “unbalanced portfolios” that are not well matched to the strategy of the firm [2].

The limitations of financial metrics are even more obvious when it comes to evaluating projects in the public sector. Public-sector organizations have social missions and may not even sell goods and services that generate cash flows. Even it they do, earning a financial return may not be a primary objective. For example, a water utility has a mission that includes serving community water needs. A public school has a mission that includes educating students. Cash flow analysis will not do a good job of indicating how well these organizations are accomplishing their missions. Financial metrics fail to measure the value of projects intended to achieve non-financial objectives.
Two Views on Organizational Value

To recap, our goal is to measure the value of a project, to enable us to prioritize project opportunities and decide which projects to do and which not to do. Since the decision to do a project is based on a belief that the project will create value for the organization, project value is logically the value of the organization with the project minus the value of the organization without the project. The most popular way of measuring business value is using discounted cash flow analysis, but that approach ignores any benefits of projects that cannot be expressed as impacts on cash streams. If cash flow analysis is inadequate, what other methods exist for measuring organizational value?

Management scientists have long argued over two competing views on how to measure the value created by an organization, based on the answer to the question, “Value to whom?” The first view is that the purpose of organizations is to produce value for owners (shareholder value). The second view is that successful organizations must create value not just for owners, but for other stakeholders as well (stakeholder value).

Shareholder Value

Historically, most management scientists and U.S. business leaders have argued that the fundamental objective of investor-owned organizations is to maximize value for the owners of the business. In the case of a publicly traded company with one type of stock, shareholder value is roughly the number of outstanding shares multiplied by current share price. Dividends increase the return to shareholders while simultaneously decreasing share price. For both theoretical and practical reasons, increasing market value can be argued to be the primary goal of many private-sector businesses.

One argument for shareholder value is the objectivity of market valuations. Market prices are objective and applied consistently across all publicly held companies and markets. If they were not there would be opportunities for arbitrage; that is, one could buy shares of a company at a lower price in one market and simultaneously sell them at a higher price in another market.

Irrespective of theory, seeking higher stock value is clearly a practical objective for senior management. Compensation for top executives is often tied to stock performance. Poor stock performance is a common reason for a company’s board of directors to consider replacing its chief executive. A company whose stock is depressed because it is not effectively managing for shareholder value is a candidate for investor takeover.

It is important to understand that managing for shareholder value and managing for profitable cash flows are two very different things. The figure below compares the market values and risk-adjusted discounted values (NPV) of projected future earnings for four companies in the same industry. In each case, the discount rate for computing the NPV is the company’s weighted average cost of capital.
As illustrated, a company’s market value is usually higher than the NPV of its earnings. In the literature on real options, the additional value is termed “option value.” In addition to projected future cash flows, market value depends on how buyers and sellers in the marketplace perceive, among other things, the ability of the business to obtain and respond to future opportunities and avoid future threats.

Also as shown in the figure, it is not uncommon to find two companies in the same industry such that one has a higher NPV of projected returns but the other has a higher total market value. Indeed, some “dot com” companies have substantial market values yet cannot convincingly forecast any profits. Option value does typically eventually translate into earnings. However, because it is generally difficult or impossible to forecast the exact mechanisms by which this will occur, option value and other indirect sources of value will not be represented in accounting forecasts of cash flows.

The implication of the above is that impacting cash flows is only one of several paths by which projects can influence shareholder value. The alternative paths that may be relevant depend on the nature of the organization’s business. For example, a project that generates new knowledge that improves consistency of execution can reduce investment risk. This can have the effect of lowering the cost of capital and increasing the returns on the capital invested. Investors seeking investments likely to increase in value will buy more shares, which will increase shareholder value. As another example, a service company might conduct projects that enable it to meet commitments or promises to customers. This improves customer perceptions and can influence the views and reports of Wall Street analysts, resulting in higher stock prices.

According to the perspective of shareholder value, the appropriate metrics for evaluating projects in the private sector are those relevant to forecasting impacts on the market value of the business. Real options analysis and related methods are designed to do this. Companies that evaluate projects by estimating impacts on profits alone ignore a significant component of market value.

**Stakeholder Value**

The alternative view, gaining popularity, is that firms should create value for all stakeholders, not just shareholders. Stakeholders are groups of people who have an interest in the business or organization (Figure 20). From the perspective of the organization, the most important stakeholders are those groups whose attitudes and actions can have an important impact on its success. Stakeholder value may include creating value for employees, suppliers, customers, the local community, and society at large.
Proponents of narrower shareholder value argue that there is no need for firms to try to create value for other stakeholders because the pursuit of self-interest and economic efficiency automatically creates value for all. If customers voluntarily buy a company's products, the value they place on those products is greater than the cost, meaning that customers gain value through their purchases. Likewise, workers gain value through their employment, and the taxes the company pays benefit communities. Furthermore, the more successful a company becomes the more value it will create for others. This logic is commonly referred to as the "invisible hand of the free market." The most successful companies create the products and services that customers want most at the lowest price. Rising stocks attract more investors, which enables them to satisfy even more customers and hire more employees. The tax system then ensures that successful companies create tax revenues for social ends. Even cost cutting through outsourcing, according to this view, is socially beneficial. Suppose, for example, a firm outsources its manufacturing to an underdeveloped country. The wages it pays those workers will enable them to become consumers, which will spawn new local businesses to provide things that those new consumers want. Increasing job opportunities will cause wages to increase. Eventually, higher wages will reduce incentives for companies to outsource to the previously poor countries.

One problem with the invisible hand argument is its assumption that the markets within which firms operate are "perfect," such that stakeholders other than shareholders are unharmed by the firm's focus on benefiting shareholders alone. For example, if employees are laid off, it is assumed that they can immediately get equivalent jobs elsewhere. Similarly, if suppliers or consumers are mistreated, they can take their business to other firms. Another problem is externalities--situations where the actions of a firm produce impacts on others who do not pay or are not compensated. Externalities cause free markets to malfunction, producing, for example, too much pollution and too little basic research. Recent well-publicized accounting and investment scandals, declines in the housing market, volatile oil prices, and the difficulties job seekers experience in relocating or changing professions raise serious questions about the effectiveness of the invisible hand. Some critics of shareholder value have claimed that the current economic decline was largely caused by excessive risk taking by companies fueled by
shareholder demands for ever higher levels of short-term gain.

Proponents of stakeholder value believe that a narrow focus on creating wealth for business owners doesn't lead to the best social outcome. Instead, they argue, organizations ought to consciously consider the impact of their actions on all stakeholders and seek to create value for all stakeholders. The degree to which companies are successful is a function of how much stakeholder value they create.

Even the staunchest proponents of shareholder value are unlikely to argue that the concept provides a useful guiding rule for organizations not in business to make money. For non-profit and public-sector organizations, stakeholder value is the natural measure of success. Likewise, companies in regulated industries are often required by their regulators to serve the interests of customers, citizens, and other stakeholders, so seeking to maximize stakeholder value makes sense.

Companies, including those that only care about shareholders, are increasingly recognizing the need to be mindful of how their actions affect other stakeholders. If they don't, they risk conducting (or failing to conduct) projects needed to prevent adversely impacting the interests, attitudes, and perceptions of workers, customers, regulators, and local citizens and/or public officials. The animosity so generated can harm the business. A company seeking to grow its stock price would be foolish to ignore significant concerns of its stakeholders. Careful investors factor considerations such as employee relations, customer satisfaction, regulator attitudes, and community perceptions into their investment decisions. Significant impacts on stakeholders inevitably affect shareholder value.

Proponents of stakeholder value argue that the benefits to shareholders may be less obvious, but are real and long-lasting. Businesses that serve the needs of all stakeholders tend to gain efficiencies, enhance their reputations, and create new markets. Projects that benefit the local community ultimately help the business, since healthy communities tend to contain well-educated, skilled workers and generate more local demand for products and services. Furthermore, a thriving community is more likely to provide the infrastructure and a supportive environment important for business success. Thus, there are competitive advantages for businesses that actively pursue stakeholder value that may be more sustainable than the conventional cost and quality improvements that have traditionally been the focus of executive attention.

**Stakeholder Value Is Not Shareholder Value Practiced with Corporate Responsibility**

Recognizing the importance of managing relations with stakeholders, many companies are implementing "corporate responsibility" programs. It might seem that pursuing stakeholder value through socially acceptable means produces the same results as adopting the goal of maximizing stakeholder value. However, this is not the case. Seeking to maximize stakeholder value produces different priorities and project choices compared to most corporate responsibility programs.

Here's why. The typical corporate responsibility program is an independently managed effort funded by diverting a portion of available corporate income to projects that produce socially desirable ends. The rest of the company remains focused on maximizing returns for shareholders. Basically, the company imposes a constraint on itself—X dollars will be spent on generating shareholder value and Y dollars will be spent on things other stakeholders want. The company accepts less shareholder value in return for achieving something good for society. Even if the corporate responsibility program attempts to maximize stakeholder value, the outcome will be less value for both shareholders and stakeholders.
because imposing constraints inevitably reduces performance.

In contrast, truly adopting stakeholder value means that all investments across the company will be evaluated in terms of the total value created for both shareholders and other stakeholders. This perspective favors win-win opportunities. For example, an investment in a wellness program for employees might be a priority under stakeholder value because it would result in healthier families and reduce employee absences and lost productivity. Likewise, spending a bit more for a technology that improves environmental performance could be especially attractive if it yields a net cost savings through enhanced resource utilization and process efficiency.

**Maximize Value Creation**

Regardless of one’s stance in the debate on shareholder versus stakeholder value, the correct logic for selecting projects is maximizing value creation. As is the case with shareholder value, effective methods are available for quantifying stakeholder value. The appropriate project valuation metrics are those that result from applying these methods. As shown in the next sub-section, the right metrics can be found by constructing a project-selection decision model that evaluates projects and project portfolios based on the goal of maximizing value (shareholder or stakeholder value).
Project-Selection Decision Models

So, if the goal is to choose projects based on value generated, what kinds of metrics reflect impacts on value? Many organizations have trouble answering this question. Organizations tend to measure what's easy to measure, not necessarily what's important or useful. Most organizations use a bottom-up approach. They define interesting metrics, but then can't come up with the equations or algorithms for computing project value based on those metrics. They end up using arbitrary aggregation equations, such as weighted summations, or vague and unjustified concepts, such as "balance" or "strategic alignment." Unless there is a logical way to combine metrics to determine the value added by projects, the metrics will not be of much help for identifying value-maximizing project portfolios. How do you determine the metrics and associated equations for computing the value added by projects?

Create a Decision Model

The answer is—You need to reverse the process, use a top-down approach and create a project-selection decision model [3]. A decision model is an analytic representation, typically implemented in software that captures the key considerations for decision making and derives recommended choices from them. As illustrated in Figure 20, the three basic components of a decision model are: (1) the alternatives that are available (what you can do), (2) objectives and preferences (what you want), and (3) information and beliefs about what will happen depending on the alternative that is selected (what you know, believe, or suspect).

![Figure 20: A project-selection decision model represents the 3 components to a decision.](image)

To support decision making, a decision model needs to capture understanding about (1) what might likely happen depending on the alternatives that are selected, and (2) how desirable or undesirable those consequences or outcomes would be. The model is expressed in terms of variables and mathematical relationships.
If the decision model is a project-selection decision model, it will likely take as input characteristics of the project, the project's anticipated impacts, and other factors, and produce as output the value that would be added by doing the project. As indicated in Figure 21, such models generally consist of two sub-models. The first (labeled "simulation") specifies or generates the relevant consequences of doing the project. This sub-model is a “consequence model,” it captures or predicts the possible consequences of selecting alternative projects by incorporating the facts, judgments and uncertainties relevant to project selection. The second (labeled "valuation") computes the value of those consequences. Termed a “value model,” its purpose is to evaluate the potential decision consequences by incorporating decision-maker values and value tradeoffs. Since the value of a project is what the organization would logically pay to obtain the project consequences, value are expressed in dollar (or other currency) units. The model may be used to identify those project choices that maximize value added.

![Figure 21: A project-selection decision model values projects in two steps.](image)

Decision models are created the same way that other types of models are constructed. The variables to use in the model are selected, the mathematical relationships among those variables are determined, and the parameters of the model are quantified based on available data together with new information that can be gathered. The process is as much art as science, however, in the case of decision models, an effective step-by-step model-building process has been developed. The process, described below, is based on multi-attribute utility analysis (MUA) (also called multi-attribute decision analysis or multi-objective decision analysis–MADA or MODA). The approach constructs a decision model "from the top down," beginning with the definition and structuring of objectives.

**Structuring Objectives**

Structuring objectives means appropriately defining, characterizing, and organizing the objectives for conducting projects into an objectives hierarchy. The objectives in the hierarchy define the ways in which projects might create value, since a project that contributes to the achievement of any objective produces some amount of value depending on how much that particular objective is advanced and the importance of advancing that objective. The key is to structure the objectives hierarchy in such a way that the mathematical equation for correctly aggregating the various value components (the aggregation equation) can be derived from the hierarchy.

Procedurally, the process for constructing an objectives hierarchy begins with identifying the organization's highest-level, most fundamental objective. Then sub-objectives that specify or clarify
how that fundamental objective may be achieved are identified and added. Typically, objectives are stated in terms of maximizing some desired, or minimizing some undesired, object of interest. The process of identifying and adding sub-objectives continues to the extent necessary to produce a comprehensive and sufficiently detailed mapping of how projects can create value.

For example, suppose the organization's fundamental objective is maximizing shareholder value. As shown previously (Figure 19), shareholder value may be regarded as the net present value (NPV) of the company's projected cash flows plus option value. Thus, a shareholder value objective could be split into two sub-objectives: (1) maximizing the NPV of future cash flows and (2) maximizing option value. Relevant sub-objectives for increasing NPV would include (1) increasing future revenue and (2) decreasing future costs. Sub-objectives for maximizing option value depend on the organization and the nature of its business, but generally such sub-objectives involve achievements that would increase the ability of the organization to identify and take advantage of future opportunities and avoid future risks, as well as other sub-objectives that, if achieved, would enhance investor expectations and, therefore, increase the market value of the company.

![Figure 22: Sample objectives hierarchy for shareholder value.](image)

If, on the other hand, the fundamental objective of the organization is maximizing stakeholder value, then the objectives hierarchy may be established by identifying who the stakeholders are and then identifying and structuring their objectives. An example of an objectives hierarchy for a case wherein the organization's fundamental objective is to maximize value for stakeholders is provided in a following sub-section.

Much has been written about how to define, characterize, and structure decision objectives so that the mathematical form of aggregation equation for combining value components can be derived. Basically, the goal is to specify objectives that are (1) fundamental (a common error is to specify as an objective something that is only one means for achieving what is really desired), (2) well defined (such that people readily agree on the meaning of each objective), (3) measurable (it is possible to know and measure how well each objective is being achieved), (4) comprehensive (the set of objectives is sufficiently complete to capture all of the strengths and weaknesses of available alternatives), and (5) non-redundant (at any specified level of the hierarchy, there is no overlap or double counting among the objectives at that level). A serious and all-too-common error made by those designing project selection
and prioritization models is to assume that value components can be weighted and added when an analysis of the associated objectives hierarchy would prove that this is not the case (more discussion on this is provided later).

**Characterizing Distinctions**

Once objectives have been structured, the next step for constructing a decision model is specifying measures for characterizing the distinctions that determine how well the objectives are being achieved. The distinctions that we seek to identify are the attributes or characteristics that we care about. For example, suppose the context is decision making by a utility that distributes electric power. Customers (and therefore the utility) care about power outages, so one distinction that matters when thinking about electricity delivery is whether or not power is available to the customer. Any measure we define must have at least two possible states, for example, "yes power" or "no power," but we can define measures to have many more states if it helps us to differentiate alternatives and measure how well we are achieving our objectives. For example, the measure for electric power to the customer could be defined as the average annual number of hours and minutes that the customer is without power. If there are additional sub-objectives relevant to providing electric power, measures may be defined for those as well. For example, if customers should be spared from brownouts, the voltage available from the customer's power outlet would be relevant, which, for example, could be could be zero, 110 volts, 109 volts, 108 volts, etc.

As illustrated by the above example, multiple measures may be required to characterize with adequate precision the multiple sub-objectives that determine the achievement of a particular decision objective. In general, sub-objectives and associated measures should be defined whenever (1) the degree to which the objective is achieved depends significantly on performance against that measure, (2) performance against the measure doesn't track or exactly correlate with performance against some other measure that has already been defined (i.e., you need the additional measure to distinguish possibilities), and (3) available understanding is sufficient to conclude that the level of performance against the measure will differ depending on the project choices that are made (i.e., the measure differentiates among the alternatives).

Measures must be defined for each of the lowest-level sub-objectives in the objectives hierarchy. For example, customers care about the accuracy of their bills. Thus, the percentage of customer invoices with errors might be a relevant measure for an organization considering projects for improving customer billing. As an example relevant to measuring option value, customer brand loyalty might affect investor expectations. A possible measure for impact on brand loyalty might be the percent of customers making repeat purchases or the company's ranking in customer satisfaction surveys.

The selection of measures is one of the more creative aspects of model building. In addition to choosing measures that quantify the achievement of the objectives, measure selection should be based in part on the types of data the organization does or can collect to assess performance. Influence diagrams (illustrated in a following sub-section), can be very effective for identifying useful performance measures.
Describing Possibilities and Likelihoods

Measures that characterize the distinctions that matter provide the framework needed to capture project consequences. To illustrate the concept, imagine that we combine the measures that we've defined into a tree structure. The tree starts with a set of branches indicating the possible states for the first measure, which are connected to branches for the second measure, and so forth. The paths through the tree define all of the possibilities, and that set of possibilities is the same regardless of the order in which the tree has been drawn. Some of the possible combinations will, of course, be more desirable than others, and it will be the job of the value model to sort this out (see the next section). The job of the consequence simulation model is to capture how the choice of project alternatives affects the likelihood of the various performance combinations (paths through the tree).

Sometimes, a project choice that we make will ensure that we end up on a specific branch for some measure (reflecting a specific outcome or level of performance for that measure). For example, if the electric utility from the example above conducts a project to add a distribution line that will reach 100 new homes, and the number of residential customers receiving service is a measure of performance, then, assuming the project is successfully completed, the number of customers will be incremented by 100. If there is uncertainty about project consequences, a choice merely affects the likelihood of the various branches for that uncertain measure (e.g., the number of new customers that will be added is somewhere between 0 and 100, depending on how many of the new homes in the housing development that the line will serve will be built and sold to homeowners).

The above illustrates that one way to capture the relevant beliefs about the consequences of choices is to assign probabilities to the possible performance outcomes that correspond to the paths through the tree of possibilities. We could do this by assigning probabilities to the branches for the first measure, conditional probabilities to the branches for the second measure (that indicate how likely each level of performance is for the second measure given each possible level of performance for the first measure), and so forth. If we then multiply all of the probabilities along any path, we will obtain the probability of that scenario. Since the goal of the consequence model is to express our beliefs about how choices affect our ability to achieve the distinctions we care about, a modeling approach based on assigning probabilities to the branches in a tree of possibilities would provide a fully adequate consequence model.

Creating a Consequence Model

The purpose of above description is not to suggest that developing a tree structure and assigning probabilities is always the best way to construct a project consequence model. Rather, it is to demonstrate the basic problem that must be solved and to illustrate that there is at least one solution approach that will always work. Consequence models built on tree structures (e.g., decision trees and event trees) are, in fact, quite common. For example, for evaluating pharmaceutical projects, tree models are typically used to lay out the likelihood of success and timing and to simulate the outcomes of the various tests and regulatory approvals that are required.

There are, however, many other model forms that may be used to infer or simulate project consequences. The simplest (and perhaps most common) approach is direct estimation (What do you think will happen if the project is conducted?). A popular approach for the case where data are available on the outcomes of similar projects is to use statistical analyses to establish correlations and suggest
cause-effect relationships between project characteristics and project consequences. Sometimes sophisticated simulation models are available for estimating project consequences. Many states and municipal governments use transportation simulation models to predict the impacts of transportation projects on traffic congestion, travel times, pollutant emissions, and other consequences of concern. The models may simulate the paths of individual vehicles along a particular road, or operate at a more macroscopic level, representing, for example, the speed, flow and density of traffic in the various sections of a transportation network.

Importantly, there are many existing models for measuring performance against numerous types of business and organizational objectives. For example, perhaps the most common sub-model used in project evaluation is the financial, or "business case model". The typical project financial consequence model computes the NPV of cash flows from the project (free cash flows), accounting for the timing of incremental costs and revenues, taxes, the time value of money, and other considerations that affect the equivalent, current financial worth of the cash flows to the business. Thus, project consequence models typically include a cash-flow NPV model as the sub-model for measuring the project's direct financial benefits.

Other models have been developed for capturing understanding regarding many different processes, activities, and impacts relevant to evaluating project impacts on business objectives, and these models can likewise be utilized. For example, there are well-established models for estimating R&D success, the impact of project characteristics on customer choice, the rate at which new products penetrate exiting markets, the effectiveness of projects at reducing pollution, the productivity and reliability of business assets, and so on and so forth. Selecting, customizing, refining, and piecing together various sub-models that have worked well in other applications is the most common approach for creating the consequence model component of project-selection decision models.

**Valuing Consequences**

Project consequences must be valued in a common unit of measurement; otherwise they can't be combined to obtain a total project value. Since financial gain is an expected consequence for many projects, dollars (or another unit of currency) is the obvious choice for valuing all project consequences, including non-financial benefits. Because people regularly use money to make transactions, it is easy to interpret worth in monetary units. Also, unless we express project value in the units used to measure costs, we won't be able to determine whether project benefits justify project costs. Money is the clear choice for the unit for measuring project value.

One approach for determining the monetary value of potential project consequences would be to ask the organization's leaders to provide the numbers directly. However, the task would be difficult and it would be hard to obtain consistent answers. Thus, methods based on formal theory and analysis are used instead. The available theories and methods for quantifying project value are presented in the next section of this paper.
Choosing the Wrong Portfolio of Projects

Part 3: Lack of the Right Metrics

Quantifying the Value of Projects

Our goal is to enable organizations to identify and, therefore, select the projects that create maximum value subject to the constraints on available resources. To do this, we need to be able to quantify the value of projects. Organizations conduct projects because they expect the consequences of doing those projects to be useful to them. They believe they will be better off if they expend the required resources to do a chosen project than if they don’t spend those resources and don’t do that project. In other words, organizations choose to do projects when they believe the consequences of those projects are worth more to the organization than what they must spend to obtain the consequences.

We define the value of a project to be the maximum the organization would pay to obtain the project consequences. Thus, the value of a project is the worth, to the organization, of the anticipated consequences, including consideration of any and all uncertainty over what those consequences might be. Since it would be difficult or impossible for the organization’s leaders to estimate the most they would pay to obtain the consequences of each candidate project, we desire a tool or model that can perform the task. We call that tool a project-selection decision model. The first step for constructing such a model is to structure the fundamental objectives for project-selection into a hierarchy. The project selection decision model consists of two sub-models, (1) a consequence model for estimating or simulating what the consequences of projects might be and (2) a value model for converting those consequences into an equivalent monetary value. The last section explained how to create a project consequence model. In this section, I describe the theory and practice for creating value models.

Value Functions and Utility Functions

The relevant theory for value modeling was developed a half century ago. In short, there are two types of value models, “value functions” and “utility functions”. Value functions [4] are appropriate if there are no uncertainties in consequences or if the uncertainties are small. Utility functions, devised earlier by mathematicians Oscar Morgenstern and John von Neumann [5], are more general then value functions and appropriate when uncertainties are significant and the consequence model explicitly captures those uncertainties via assigning probabilities. The main advantage of a utility function is that it can account for willingness to accept risk. Value functions and utility functions provide the aggregation equation needed to combine project metrics into a measure of project value, and the theories governing utility and value functions establish the basis for judging the logical soundness of a value model.

A standard notation is used for expressing value models. Suppose there are $N$ fundamental objectives designated $O_i$, for $i = 1$ to $N$. An attribute for measuring performance against the objective, denoted $X_i$, for $i = 1$ to $N$, is defined respectively to measure each of the $N$ objectives. For example, if safety is an objective for some decision, an attribute for measuring the level of safety might be the number of fatalities occurring annually. With the standard notation, a possible set of consequences for a specified
alternative could be written as \( x_1, x_2, \ldots, x_N \), where each \( x_i \) is a specified level of the \( i^{th} \) attribute, \( X_i \). The attribute levels associated with doing or not doing a project are produced by the consequence model.

Once a set of fundamental objectives and associated attributes are defined, a value model may be constructed by associating with each combination of \( x_i \) a number indicating preferences (usually, a higher number is associated with those \( x_i \) combinations that are more desired). If the preferences for the \( x_i \) satisfy a set of assumptions known as additive independence, an additive value function may be constructed:

\[
V(x_1, x_2, \ldots, x_N) = w_1V_1(x_1) + w_2V_2(x_2) + \ldots + w_NV_N(x_N)
\]

In this equation, \( V \) is the overall value model, the \( V_i \) are "single attribute value functions" that express preferences for consequences that differ in terms of only a single attribute, and the \( w_i \) are scaling constants (i.e., weights).

When uncertainties are important so that a utility function is needed, subject to a condition known as the delta property, the value model may be expressed as:

\[
U(x_1, x_2, \ldots, x_N) = 1 - \exp^{-V(x_1, x_2, \ldots, x_N)} / R
\]

where \( U \) is the overall utility function quantifying preferences, \( V(x_1, x_2, \ldots, x_N) \) is an additive value function, \( \exp \) denotes the exponential function, and \( R \) is a constant denoting decision-maker willingness to accept risk (see the discussion in the next part of this paper dealing with risk tolerance).

If the conditions necessary for either the first or second equations above are satisfied, the construction of the value model reduces to specifying the \( V_i \), \( w_i \) and, in the case of a utility function, the constant \( R \). These components may be determined using value judgments from decision makers or by assigning numbers and relationships to represent the presumed value judgments of decision makers.

**Scaling Functions**

The single-attribute value functions, also called scaling functions, indicate the relative value of achieving various levels of performance for the attributes. If the attribute is expressed in units of something that is of value in itself, as opposed to value for its uses, then a linear single-attribute value function is typically justified. Thus, for example, if protecting public or worker safety is an objective, and number of lives saved is the associated attribute, the value would likely be proportional to the number of lives saved (if all lives are equally valued, there is no reason to value the first life saved differently than the 2\(^{nd}\), 3\(^{rd}\), or 4\(^{th}\) life saved).

With some objectives, there is no single, natural unit of measurement that expresses the degree to which the objective is met. In such cases, it is common to develop a constructed scale. Constructed scales typically have between 3 to 10 levels, with definitions expressed for the levels. Using constructed scales can also help avoid communicating a false sense of precision, which can make individuals reluctant to provide direct estimates of project performance. For example, Figure 23 shows a simple constructed scale that might facilitate estimates of how much additional energy would be provided by a utility’s proposed capacity expansion projects (presumably, satisfying the demand for electric power is a utility objective). If the constructed scale defines levels that are proportional to value (e.g., achieving a level 4 on the scale is twice as valuable as achieving a level of 2), then the associated single-attribute
value function should be linear. Otherwise, a single-attribute value function will necessarily be a non-linear scaling function that indicates the relative value of each level on the constructed scale. In the example, each level of the scale satisfies roughly ten times as much customer demand. Assuming value to customers is linear in the amount of new energy delivered, the associated exponential scaling function translates the scale level to a relative measure of value.

![Scale](image)

**Figure 23:** Example constructed scale and scaling function (single-attribute value function).

**Weights**

The weights for an additive value function can be derived by finding sets of consequences judged to be of equal value to decision makers. If, for example, consequence sets \( y = (y_1, \ldots, y_N) \) and \( z = (z_1, \ldots, z_N) \) have equal value, then:

\[
V(y) = w_1v_1(y_1) + \ldots + w_Nv_N(y_N) = V(z) = w_1v_1(z_1) + \ldots + w_Nv_N(z_N),
\]

which provides one equation in the \( N \) unknowns \( w_1, \ldots, w_N \). Thus, if \( N \) pairs of consequences with equal value are identified, we have \( N \) equations in \( N \) unknowns, which can be solved for those unknowns to yield the desired weights.

Several practical procedures have been devised to simplify the assignment of weights. One approach is to use cost-benefit analysis (CBA) to price the attribute, which may be applicable when there is a single natural measure for describing a project consequence, the single-attribute value function for that consequence is linear, and the overall value model is additive. CBA derives a monetary value per unit of a consequence based on market prices, contingent valuation (people's willingness to pay), and the hedonic price method (analyzing market prices to determine how factors impact market prices). Thus, for example, if reducing greenhouse gas emissions is an objective, and tons of greenhouse gas emissions released is the attribute for measuring performance, then CBA estimates of the equivalent dollar cost per ton of greenhouse gas released could be used to weight estimated project impacts on emissions. Multiplying the CBA estimate of the per ton cost times the number of tons by which emissions would be reduced provides an equivalent monetary value of the emissions reduction.
If there are no CBA data for monetizing project impacts, or if the values from CBA are not acceptable to
decision makers, then equivalent monetary values can be obtained by asking decision makers for value
tradeoffs. It is important that the weights not be assigned to the objectives or attributes directly.
Instead, weights must be assigned based on and then scaled to some specified change (“swing”) in the
attribute. This approach to weighting is called the “swing weight method,” which establishes a relative
value per unit of change in the attribute or scale used to measure performance. A common mistake is to
assign weights based on the judged relative importance of the objectives. Using importance weights
rather than swing weights leads to significant biases in results.

**Practical Considerations for Constructing Value Models**

Because an additive value model is simpler to construct and to use than a non-additive model, the key to
designing practical value models is ensuring that as much of the model as possible is additive. This is
why the design process begins with structuring objectives. If the objectives are fundamental objectives
and meet the other criteria specified above, then it is very likely that an additive value model can be
shown to be appropriate. The main cause of non-additivity is the use of means objectives in the value
model.

In practice, value models are typically designed with mostly additive terms, but with some non-additive
terms. The non-additive portions of the model can often be derived directly from a few simple, well-
established assumptions. For example, timing and duration of project benefits are often relevant to
project value. The common practice of discounting and summing the value of the time stream of
impacts that occur in the future can be derived from just two assumptions: (1) that investors wish to
maximize their wealth and (2) that a market exists that will provide a return from investing cash.
Frequently, the non-additive portions of the value model involve multiplications, or other
straightforward and obvious mathematics.

Because value models have been successfully developed for hundreds of different types of decision
problems, generic objectives that work well for most types of decisions have been identified. For
example, organizations often find that objectives related to maximizing financial return, increasing
customer satisfaction, protecting and enhancing corporate image, and increasing organizational
capability are relevant to selecting projects. Attributes, scales, and sub-models for quantifying the value
of these and many other common types of project benefits are available.

For potentially controversial dollar conversions, such as for safety and environmental impacts, rather
than assign weights directly, many organizations find it convenient and less controversial to leverage
results from CBA, academic research, government recommended values, and values adopted by other
organizations. Sensitivity analysis, that is, varying weights across a range to see whether it changes
decision recommendations, is commonly used to demonstrate that most project decisions are not overly
sensitive to the dollar conversions assumed for specific project outcomes.
Is It Hard to Create a Project Decision Model?

The prospect of creating a model that quantifies the dollar value of projects no-doubt sounds hard. Building a decision model requires developing and documenting understanding of what your organization does, how it does it, and how the choices that are made determine the value that is created. This understanding is critical to knowing what to do to create organizational success. Thus, one could argue that using decision modeling to identify project evaluation metrics merely forces the organization to do what it should be doing anyway.

Actually, building a decision model is not as difficult as it may sound. In my experience, the basic design for even a sophisticated decision model can be structured in a 3-day framing workshop (using techniques based on value modeling, influence diagramming, and cause-effect reasoning). The resulting qualitative model can then be quantified fairly quickly by refining and piecing together pre-existing sub-models and using well-established relationships for estimating various types of benefits. As noted previously, in addition to project financial value, standardized sub-models are available for quantifying health, safety, and environmental value; customer value derived from new products and services; brand image value, learning value; and so forth. The combined model captures business understanding in relevant areas such as R&D, engineering, manufacturing, marketing, sales, IT, customer relations, legal counsel, regulatory affairs, etc. The result establishes an explicit connection between the project, the impacts the project would create, and the value of those impacts.

An Example

Figure 24 (next page) provides an example. The figure is a graphical representation of a portion of a project-selection decision model developed by a team at an electric utility. The figure provides detail only for that portion of the model for measuring project value attributed to improving electric service reliability.

The upper part of the figure is a hierarchy of objectives for selecting projects. As indicated, the utility adopted stakeholder value as its overall objective. Key stakeholders were identified to be shareholders, customers, workers, citizens, and others (e.g., business partners, elected officials, some state and federal agencies, etc.). The sub-objectives for stakeholder value represent the fundamental concerns of the various stakeholders: (1) the utility’s financial performance; (2) health, safety and the environment; (3) satisfying customers (both existing customers who want high-quality service and anticipated new customers, e.g., people who might live in future housing developments) who will desire electric service; (4) satisfying other stakeholders (e.g., responding to regulator concerns and maintaining a good image with the citizens of local communities), and (5) building a platform for future success (providing learning, improved capability, flexibility, ability to respond quickly, etc.).

The middle part of the figure is the influence diagram constructed for the service reliability objective. It identifies the factors, relationships and metrics assumed to determine the level of satisfaction derived by customers based on the reliability of the electric service provided. As indicated by the nodes and arrows in the diagram, the utility believes that a customer’s level of satisfaction with service reliability depends primarily on the frequency and duration of the outages that the customer experiences—the fewer
outages experienced and the shorter the duration of those outages, the happier the customer will be.

Figure 24: Portion of a project selection decision model for an electric power delivery company.

The bottom portion of the figure indicates how the reliability component of the decision model was
quantified. As indicated, the service reliability sub-model takes as input the metrics identified in the influence diagram and produces as output its measure of reliability performance: “total weighted annual customer minutes out.” This performance measure assumes that the level of customer dissatisfaction is roughly proportional to the total amount of time that the customer is without power (some utilities use a scaling function to indicate that particularly long outages, for example, outages that would cause food in refrigerators to spoil or companies to send workers home is proportionally more costly). Finally, through weights assigned to different customer types, the model reflects the assumption that outages are more harmful or costly for some types of customers than for others. This utility chose the weights for residential, commercial and industrial customers based on industry studies estimating the actual dollar costs of outages to these various types of customers. In addition, the utility defined “critical customer” to serve as a special category with a very high weight for customers, such as a hospital, where reliability of service is judged to be especially important.

The sub-model for measuring reliability benefit works as follows. If a proposed project will impact service reliability, the project proponent estimates the scope of impact (How many residential, commercial, industrial, and critical customers will be impacted?). These numbers can be derived based on the configuration of the utility’s distribution network and the specific components of the network that the project will impact. In addition, forecasts are provided for the number and duration of outages experienced by these customers (1) if the project is not conducted and (2) if the project is conducted. These forecasts are made by extrapolating data on historical outages within the project scope and based on estimates for how the proposed project will affect system reliability. The measure of project reliability benefit is total weighted customer outage minutes avoided, and the value is expressed in dollar terms based on the weights assigned to the customer types.

To illustrate another aspect of this decision model, Figure 23 shows how the value of serving unmet energy needs was quantified. The assumption is that providing power to new customers creates value for those customers because the value derived is greater than the price charged. (This principle is termed “consumer surplus” by economists.) To estimate the value of projects that provide this benefit, the following logic is used. First, the expected shortfall in energy delivery is estimated based on forecasts of growing energy demand relative to the capacity constraints of the existing electric distribution network. If increments to capacity are not put in place, new homes will not be built and businesses will not expand because the required electric service cannot be assured. In the utility industry, the shortfall in delivery relative to forecast demand is referred to as expected unserved energy (EUE), and it is measured in kilowatt hours.
Figure 25: The utility’s sub-model for new energy delivery.

The black curve in Figure 25 shows the results of such a forecast of EUE (the “jumps” in the curve in the early years correspond to the completion of known residential and commercial development projects; the curve increases smoothly in later years because in this time frame the forecast is based only on estimated average annual growth rates).

The second step is to forecast the EUE that would exist if the project is conducted. The EUE with the project (the red curve shows a sample forecast) is obtained based on the schedule by which the project would bring new capacity on line (this determines the shape of the curve in the initial years), the total amount of new capacity provided by the project, and the point in time when the new capacity would be fully utilized (this determines the gap between the two curves in the later years). The difference between the two curves represents the EUE avoided (in kilowatt hours). To convert EUE avoided to a dollar value, the utility again uses data from willingness-to-pay surveys.

**Too Complicated?**

If this sounds a bit complicated, consider that the utility using the above-described decision model spends hundreds of millions of dollars each year on new projects. Yet, limitations on resources means that many project proposals must be delayed or killed. If the improved decisions that result from the formal decision model and associated priority system only increase the value derived from projects by a few percentage points, the required effort is easily justified by the value gained in just the first year of model use. Furthermore, a quality decision model can be a very effective way of explaining decisions. Managers increasingly are put in the position of having to explain, "Why we did what we did." Finally, the system enables managers to demonstrate exactly why they need the resources they are requesting, the benefits that they expect to deliver, and the consequences of trying to perform with too few resources. The utility in the above example has presented its decision model to its regulators and used model results to help explain and defend its project choices as well as proposed rate increases that would enable it to conduct additional projects.

Less complicated decision models are typical for organizations with smaller project budgets, less complicated decisions, and less need to defend choices to outsiders. However, the basic principles for building the decision model are the same.
Although organizations may be initially uncertain about many of the relationships that must be specified to define their project decision models, understanding these relationships is key to success. Again, the management science and industry science literature contains numerous, often business-specific sub-models for estimating and measuring performance. Thus, as noted previously, the process of defining the relevant computations typically involves selecting and combining elements of previously developed and accepted approaches. Organizations that create explicit project-selection decision models document current best-understanding. As understanding improves, they revise their models and thereby further improve their ability to optimize their project portfolios.

**Decision Model Uses**

Creating a decision model takes work, but it is worth it. Having a decision model is critical to making consistent, intelligent choices. Knowing project value allows you to determine whether the project should be done at all, and whether, after it has been started, it should be continued. Knowing the value of your various project portfolios tells you whether you are allocating too much or too little to each, and enables you to determine the right allocation of resources across your various organizational units and business functions.

A decision model has other uses as well. For example, a decision model provides a way to estimate the value of a day of additional effort, the value of a product feature, or the value created by expending a dollar more of project cost. The project team or portfolio manager can use the decision model to illustrate how a marginal change in resources, say plus or minus 10%, might affect the overall value to be generated. A decision model is a means for explaining and justifying the resources required for doing projects.

Finally, the decision model sends important signals to those who propose and manage projects. The decision model tells engineers and others what project characteristics and attributes are valued in the funding process. It tells managers who execute funded projects what performance is expected if the project is to create the value that motivated its funding.
The Scientific Method

My advice that organizations create a project-selection decision model in order to define project evaluation metrics is nothing more than a recommendation to follow the "scientific method." The scientific method refers to a multi-step process that forces a careful, deliberate approach to building and validating new knowledge. It is the process scientists use to develop accurate (that is, logical, reliable, and non-arbitrary) answers to tough questions.

The scientific method was formalized in the early 1600’s by the lawyer and philosopher Francis Bacon. Bacon, who was heavily influenced by Copernicus, was critical of the then common scholastic approach to learning wherein accepted authorities would deduce broad “scientific truths” from limited observations. For example, casual observations of the night sky led people to conclude that the planets circle the earth, not the sun. Copernicus had a difficult time reversing this belief.

Bacon, in his book “The New Organon” (Greek word meaning tool or instrument) argued that “whatever the mind seizes and dwells upon with particular satisfaction is to be held in suspicion.” To address the bias, he proposed an inductive form of reasoning committed to empirical evidence that would build understanding through a series of steps. Figure 26 provides one representation of the scientific method.

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Figure 26: Developing a decision model is an application of the Scientific Method.

1. Pose the question that you want answered (e.g., What is the value of a project?)
2. Collect information, apply reason, investigate potentially applicable theories.
3. Regardless of complexity and based on available understanding, develop a model (hypothesis) for answering the question.
4. Do “if-then” thought experiments—Does the model produce reasonable answers?

If no, revise the model.

If no, use the model to make predictions—Are actual results consistent with model results?

If yes, use the model to make predictions—Are actual results consistent with model results?

Use the model to make predictions—Are actual results consistent with model results?

Revise the model.
Choosing the Wrong Portfolio of Projects

Part 3: Lack of the Right Metrics

The scientific method embodies several important principles. The first is that the problem to be addressed should be formulated in terms of the specific question you want solved, not in terms of some other question that you think might be easier to answer. Since the goal is to select projects that create maximum value, the relevant question for choosing projects is, “What is the value of the project?” In contrast, none of the following questions about which much has been written address what we really want to know: “How do we measure balance?” “How do we measure project alignment? What are potentially useful project metrics?”

Second, because the scientific method is fact based, information relevant for solving the problem is collected. In this case, such information includes understanding of the goals of organizations, how projects impact success, and the relevant theories for measuring value.

Third, a model (hypothesis) is constructed to explain the relevant phenomenon. For our purposes, the necessary model is one that predicts the consequences of doing versus not doing proposed projects and assigns a value to those consequences. The model provides a causal explanation for what is observed (that some projects produce more highly-valued consequences than others). Finally, central to the scientific method is the concept of testing and refining the model. This can involve "thought experiments" or the comparisons of real-world observations with model predictions. Will the projects that the model predicts will produce highly-valued consequences actually produce those consequences? Whenever inconsistencies are observed, understanding is refined and the model is revised accordingly.

A decision model is not much different from the types of conceptual models developed in other areas addressed using the scientific method. Because the model is quantitative, it allows statistical measures of the reliability of the results to be established. Initially the decision model may be constructed based on judgment, but it is tested and refined based on facts and observations. The key is that the model is available for scrutiny by people other than those who developed it originally. Individuals with specialized expertise, experience, or knowledge can spot questionable assumptions and suggest refinements. Thus, decision models have a built-in tendency to get better. This is why scientists claim to "stand on the shoulders of the giants who came before them." The key to progress is defining rigorously logical, explicit relationships that can be quantified with estimates that can be tested and refined over time.

**Scorecards and Strategic Alignment Are Not Decision Models**

The majority of currently available, project prioritization and portfolio management software tools provide capability for defining both financial and non-financial metrics. The tools are often based on a balanced scorecard approach. Scoring scales are developed to measure project contribution to various non-financial objectives. The scores are weighted and added and combined with financial metrics to provide a “balanced” measure of project performance. This aggregate measure is then used to prioritize projects. Scorecards are useful in some contexts, but the way that they are defined means that they cannot properly prioritize projects.

The following example, taken from a case study used in a Stanford University professional development course, illustrates the problems experienced by those who use balanced scorecards to prioritize projects [6]:

“When Inspire Pharmaceuticals, a North Carolina-based biotech company, first started managing its
pipeline of products for diseases of the eyes and lungs, it used an approach familiar to many: the Balanced Scorecard. Eight criteria were ranked by importance on a scale of 0 to 10. Each project in the pipeline -- discovery, development, or commercialization -- was classified by how well it met these criteria.

“With a potential range from 0 to 100, in theory this approach could provide guidance as to which projects to fund and which to drop.

“In reality, though, the top ranking project differed from the bottom ranking project by just 9 points on the 100-point scale, and nothing scored higher than 35. Not only that, but the projects at the top of the list were in late-stage development, and future expenses to commercialize were likely to be high. The projects at the bottom of the list were found to be those in early research; did it make sense to kill those low-scoring projects when the investment at this stage was so minimal?

According to the case study, when Inspire replaced their scorecard priority system with a value-based approach using the methods described in this paper, they were able to obtain logical and meaningful prioritizations of project alternatives.

**Scorecard Problems**

There are four problems for using balanced scorecards to prioritize projects. First, and most fundamentally, the goal for selecting projects should be maximizing value, not creating a balanced project portfolio. Basic scorecard guidance advises that, "The measures represent a balance between external measures for shareholders and customers and internal measures of critical business processes, innovation, and learning for growth" [7]. Assigning weights to measures of this type implies a willingness to accept lower performance in one area (e.g., lower performance for shareholders) in return for better performance in another area (e.g., better business processes). Why would an organization want to accept less value (e.g, lower shareholder value) in order to obtain a higher score (i.e. better "balance") on some internal business process? Value maximization, and not balance, is the goal.

The second problem is that, contrary to typical scorecard mathematics, it is generally not correct to weight objectives that represent means for achieving more fundamental objectives. For example, suppose we include scorecards for measuring the impacts of a project on the quality of business processes as well as scorecards for the impacts on operating costs, customer service, etc. But, improving business processes is merely a means for achieving more fundamental objectives, including reducing operating costs and improving customer satisfaction, etc. Thus, a project might get a favorable score on process improvement, but zero weight should be assigned to this score if the value of that process improvement is completely reflected in the scores assigned to metrics that represent the fundamental objectives that explain why business process improvements are important. If the weight is not zero, there will be double counting.

Failure to account for the hierarchical nature of objectives (including the fact that means objectives contribute to the achievement of fundamental objectives) is a serious error being made by many who are designing tools for project portfolio management. For example, several websites advise, “There are four goals for portfolio management, value maximization, balance, strategic direction and the right number of projects.” There is only one goal, value maximization. The proper balance, strategic direction and number of projects are whatever is required to maximize value. A proper decision model computes the
value of each alternative based on decision maker's objectives hierarchy, taking into account how lower-level objectives relate and contribute to the achievement of higher-level objectives (Figure 22 in the previous section provided an example). A decision model provides the capability to determine the levels of performance on lower-level objectives that enable the top-level objective (value maximization) to be achieved.

A third problem is more basic—Scorecards do not implement any defensible calculus for project valuation. Contrary to the “weight-and-add” scorecard approach, it is generally not correct to add different types of value. This statement, which is well established by value measurement theories such as multi-attribute utility analysis, often comes as a surprise to people accustomed to adding and subtracting monetary (e.g., dollar) values. In fact, being able to weight and add sources of values is an exception. According to the theory of value functions, a weight and add approach could only produce a measure of value if all of the metrics were additive independent, each metric is linear measure of value, and each weight expresses the equivalent monetary equivalent of value added per unit of the corresponding metric. Additive independence requires the condition in which the value of achieving any level of performance on any one metric does not depend on the degree to which any other metric is achieved, a condition sometimes referred to as “preferential independence.” Multi-attribute utility analysis provides tests for determining whether different types of values may be added, or whether more complicated aggregation equations are needed.

Scoring methods are being advocated that involve weighting and adding scores for criteria such as project risk, internal rate of return, time-to-complete, urgency, and many other criteria that fail to pass the test of preferential independence. It makes no sense, for example, to weight and add a project's score for time-to-complete to weighted scores for other criteria that indicate the value added once the project is completed. Being quick is more valuable if the project adds a lot of value than if the project adds little or no value. Weight-and-add could only make sense, in this case, if the weights are not constants; that is, if the weight assigned to time-to-complete is a function of the ultimate value of the project. (The "weight" for a metric like time-to-complete, would, of course, be determined based on time-preference, and discounting, which is not weight-and-add, would likely be the appropriate form for in the aggregation equation.)

A sound decision model addresses these issues by specifying a logically correct way of quantifying value. Prioritizing projects using a balanced scorecard approach will distort project decisions unless the weights and mathematical form of the aggregation equation are derived consistent with a defensible theory of valuation.

**Strategic Alignment—The Most Popular Scorecard Approach**

Many providers of project portfolio management software and even some of the recent books on project portfolio management promote an “easy way” to prioritize projects:

“Prioritize projects based on alignment with strategy.” “If your budget doesn’t have room for the high-end software…, you can always fall back on alignment as a sound way to rank your projects.” “The approach needs to be really simple, so that small projects can come up with a strategic alignment rating in about 5-10 minutes.” [8]

Strategic alignment is probably the most popular of the project scoring methods being used today by organizations to prioritize projects.
Strategic alignment sounds great in principle. An organization’s projects should be consistent with and implement its strategy. But, how do you measure alignment? This is where it gets shaky. Typical advice goes something like this [9]:

1. Identify the elements of your organization’s strategy, for example, build brand value, invest in core technologies, build organizational effectiveness, and revitalize quality.
2. Rate each project based on the degree of impact you expect it to have on each strategy.
3. Add the individual ratings to provide an overall strategy score.
4. Combine this score with ratings on other criteria, such as net present value or risk.

This approach has all of the flaws identified above typical of most scorecard approaches, plus some additional problems:

- Given the subjectivity involved, it would be hard to get consistent and repeatable scores from different people for something like the “degree of impact” a project has on a vaguely defined concept like “revitalize quality.”
- How do you combine an alignment score expressed in points with a financial metric like NPV, which is expressed in dollars?
- Isn’t the goal of strategic alignment to get the project portfolios that best implements strategy? The scoring approach does something different: It favors projects that impact the numerous highly weighted elements of strategy. Suppose there are individual projects that are each extremely well-aligned with a single element of strategy. Weighted scoring will not rank these projects highly (if there are other projects that have even a mediocre impact on many elements of strategy). Thus, strategic alignment does not produce the portfolio of projects that best promotes strategy.
- How do we know that the organization’s expressed strategy is optimal? How do we know that choosing projects that "align" most closely with strategy will produce the best outcomes for the organization?

The fundamental problem is that strategic alignment is not a decision model. To review, a decision model is an analytic model that generates as output a measure of the value of a project; that is a number with the property that Project A is preferred to Project B if and only if the computed measure is higher for Project A than it is for Project B. We can easily show that strategic alignment is not a decision model in this sense by applying the four steps of the scientific method:

1. **Theory:** Is there any theory to support the idea that scoring projects based on alignment with strategy provides a measure of the value of those projects? You can find discussions of project valuation theories in many management science books and professional, peer-reviewed papers. Strategic alignment is not considered a theory of valuation.
2. **Hypothesis:** Suppose we adopt the tentative hypothesis that projects that align the most closely to the most elements of strategy will also provide the most value to the organization.
3. **Thought experiments:** It is easy to debunk this hypothesis through thought experiments. Suppose the projects that align most closely with strategy are not very effective at addressing needs, produce high risks, or cost too much. Conducting such projects won't provide the most
value for the organization.

4. **Empirical evidence:** Is there empirical evidence indicating that strategic alignment produces high-value project portfolios? I begin my training seminars on project portfolio management by asking, “Of those of you who are currently using a scoring tool to prioritize projects, how many think the recommendations being made by your tool are wrong?” On average, about 60% of the attendees raise their hands. Most users have only recently put their tools in place, so expect the percentage to go up.

In answer to those who argue that projects should be selected based on strategic alignment, because selecting projects based on value is too hard, I offer the thoughts of management theorist Russell Ackoff. Ackoff, who passed away in October 2009, believed that most problems arise out of doing the wrong thing righter: "The more efficient you are at doing the wrong thing, the wronger you become. It is much better to do the right thing wronger than the wrong thing righter! If you do the right thing wrong, and correct it, you get better."[10]
Project Valuation Metrics

Once you have a project-selection decision model, it is easy to specify metrics for computing project value. The desired metrics are "observables" (discussed below) that influence the model's value drivers; that is, those project characteristics and impacts (i.e., model inputs and other parameters) that have the greatest influence on value. Some authors call the metrics obtained in this way "performance measures", to recognize the special characteristics that make them well-suited for measuring project performance relative to generating value. Metrics for measuring project performance typically include forward-looking financial metrics, like NPV, but also factors and considerations on value paths that don't directly impact cash flows. Building a decision model leads to metrics that capture the variety of ways that projects contribute value.

In my experience, a well-designed decision model will identify metrics for some or all of the following types of value:

- **Financial value.** Metrics are needed to capture any increases in revenues or reductions in future costs that may result from conducting a project. Typically, the appropriate financial estimates are the incremental cash flows attributable to conducting the project, or standard financial metrics that are derived from such cash flows (see the next subsection for more discussion). Revenue generated from projects to develop new products is often estimated with the aid of sub-models that simulate the various development and commercialization stages, in which case metrics indicating the estimated likelihood of success at each stage are also included.

- **Health, safety, and environmental (HS&E) value.** If some projects impact the health and safety of workers or the public, or the natural environment, metrics may be needed to account for such impacts. The field of risk assessment provides many well-established metrics for this purpose. Typically, the desired metrics indicate the scope, nature, likelihood, and seriousness of the health, safety, or environmental impacts.

- **Customer value.** For organizations that sell or otherwise provide products and services, metrics that describe the impacts of projects on customers are needed. The field of economics provides measures for customer value, including the concept of consumer surplus. The field of market analysis has developed numerous customer-satisfaction metrics. Another common approach is to adopt measures that describe specific product or service characteristics that customers care about (e.g., attributes of product and service quality and price). Such models may include customer choice and market penetration models for predicting the dynamics of new sales.

- **Stakeholder value.** In addition to customers, organizations typically have other stakeholders whose attitudes and perceptions are important because those stakeholders, if sufficiently motivated, can act in ways that impact the organizations. Thus, it is important for organizations to consider and manage the perceptions of such stakeholders. Examples include organized labor,
regulators, business partners, etc. The relevant metrics typically characterize the types of stakeholders and ways in which the attitudes of those stakeholders are expressed or impact the interests of the organization. Oftentimes, metrics for stakeholder value indicate the importance of the impacted stakeholder groups (based on the sensitivity of organizational operations to the actions of those groups) and the anticipated reaction of those groups to alternative project decisions.

- **Mission value.** Public sector organizations aren't the only ones that have missions. Many private sector organizations have adopted mission statements that identify goals beyond maximizing shareholder value. The appropriate metrics in this case indicate the estimated contribution of proposed projects to the various elements of the mission.

- **Community socio-economic quality.** Some organizations conduct projects that significantly impact local communities. For example, a project to build a new manufacturing plant might create desirable jobs for local citizens. The fields of sociology and economics provide numerous metrics potentially useful for such situations.

- **Option value.** Consistent with the theory of real options, projects that contribute to the organization's platform for future success provide a source of value. For example, an IT (information technology) project may give the organization new capability. An R&D project may provide new knowledge or understanding important to the business. Also, a project may have a distinct, strategic value. Metrics may be defined that capture these additional sources of value. The key is not to double count.

As indicated by the above examples, performance measures, generally speaking, are metrics that characterize the potential benefits available from projects. To fully characterize those benefits, it is typically necessary to include metrics that indicate timing, that is, when the project benefits are likely to occur and how long they will persist, and, oftentimes, risks (e.g., the likelihood that the project will actually produce its anticipated benefits). Thus, the top-down approach wherein metrics are derived from a project-selection model often leads to a large number of metrics. This outcome conflicts with standard advice for choosing criteria for project prioritization, where authors caution against using too many. Avoiding numerous criteria makes sense for the common scoring model, since the criteria defined through a bottom-up approach will tend to overlap and double count—having more criteria increases the assessment burden without improving accuracy. However, a well-designed decision model will ensure that the metrics so obtained represent distinct sources of value. If metrics essential for representing some sources of value are omitted, the value of projects will be underestimated. Furthermore, there will be a bias against doing those projects that provide the types of value that are not captured due to the omitted measures. When metrics are obtained from a decision model, the model defines the algorithm that allows the value of a project to be computed and expressed in dollar terms.

Obviously, there is a practical limit to how many project performance measures should be used. The 80/20 rule applies. The goal should be to include the minimum number of metrics necessary to roughly capture every significant source of project value, not numerous metrics that more completely capture just a subset of components of value. In other words, don't make the mistake of defining multiple measures for capturing things that are relatively easy to address (like financial value), while omitting measures for something that may be important but hard to address (like impact on learning and capability). Since few if any projects will provide significant contributions under each type of value,
having lots of measures doesn't necessarily create a significant burden for evaluating proposed projects. Estimates need only be provided for the small subset of measures that are relevant to capturing the specific motivations for doing that project.

**Metrics as "Observables" and the Clairvoyant Test**

To the extent possible, metrics should be observables; that is, characteristics of projects or project outcomes that can be observed and measured in the real world. Since estimating project value requires forecasting the future, metrics don't, obviously, all have to be things we can observe today. Metrics can, for example, include a projected future state of some observable, for example, an improvement in a reliability-of-service statistic important to customer satisfaction.

A useful device for checking whether a metric is observable is the so-called "clairvoyant test" devised by my college mentor, Professor Ron Howard. Before accepting what appears to be a good metric, consider whether a clairvoyant could give an unequivocal value for that metric given that a project decision is made in a specific way. Oftentimes, the clairvoyant test points out inexactness of what initially appears to be a well-defined metric. For example, "customer satisfaction" doesn't pass the clairvoyant test. However, "percent reduction in recorded customer complaints" and "company ranking in the next industry customer satisfaction survey" are metrics that do pass the test.

Metrics that don't pass the clairvoyant test are vague. They create inconsistency and imprecision when used for estimating. More importantly, if the metrics are not observables, they cannot be monitored so that actual values can be compared against estimates.

**Financial Metrics**

The traditional financial metrics should be used to determine the direct financial components of project value. Project investment cost is, of course, an important financial metric for any project. Projects that impact operations (e.g., projects that create new revenues or that affect future operating costs) produce downstream financial impacts that must also be evaluated. Thus, any and all significant, incremental, period-by-period cash flows that are anticipated to result from projects should be estimated, either as a most-likely or average case or in the form of alternative scenarios. The organization's standard accounting model may then be used to determine the resulting after tax, or unencumbered "free" cash flows, which may be used to compute a project's financial NPV.

Some important principles for estimating financial value in support of project prioritization include:

- Ignore previously paid, sunk costs.
- Include opportunity costs (the opportunity cost of a resource is the value of the net cash flow that could be derived from it if it were put to its best alternative use).
- Include overhead expenses (e.g., administrative expenses, managerial salaries, legal expenses, and rent) that are directly related to a project. Indirect overhead can, if necessary, be prorated across proposed projects.
- Include "spill over" effects. For example, if a project introduces a new product or service that draws sales from existing products, include such lost revenue in cash flow estimates.
• Interpret expected project cash flows submitted in support of a project proposal as commitments to be achieved by the project manager. If there are cash flow components that are more speculative or for which the project manager cannot be held accountable (e.g., because they are contingent on events beyond the control of the project manager), specify such cash flows separately and assign probabilities.

• Identify and include any terminal cash flows, for example, cash flows expected from the disposal of assets at the conclusion of the relevant product or service lifecycle.

• Be consistent in accounting for inflation. For example, using an inflation-adjusted discount rate while ignoring inflation in estimating cash flows would result in a bias against accepting projects.

• For the purposes of prioritizing projects, remember that the project's financial benefit is its NPV exclusive of its current-period costs.

Be suspicious of long-term, positive NPVs. Keep in mind the economic axiom that excess profits (the source of positive NPV) must be zero in a perfectly competitive market. A long-term, positive NPV requires some sustainable competitive edge—being first, being the best, or being the only. Retaining that edge indefinitely would require some barrier to the entry of competitors. Consider carefully how long it will take competitors to catch up and drive profits back down.

Metrics Provide Justification for Tough Choices

One of the most under-appreciated benefits of having good metrics linked to a defensible decision model is improved justification for decisions. Author Anthony O'Donnell quotes a portfolio manager at an insurance company that implemented a portfolio management tool: "People would come to me and ask me to do a particular project...I would tell them I couldn't fit it in, but had a hard time articulating why." Metrics now allow him to give concrete reasons for turning away projects. "Their satisfaction immediately went up, and I still didn't do their projects!"[11].

Each Organization Needs Its Own Metrics

Different organizations conduct different types of projects. The metrics for evaluating new product investments by a software vendor, for example, will be different than the metrics needed to evaluate process improvements for a company operating an oil pipeline. Also, different organizations create value in different ways. An electric utility, for example, creates value differently than does a ballet school. Some organizations will seek to maximize shareholder value, while others will want to value impacts to other stakeholders as well. Thus, each organization will have a different model for how its projects create value and, therefore, will want to use different metrics. There is no one set of project metrics that works for every organization. However, in all cases, good metrics provide a means for computing the value added by projects. Good metrics are observables. And, they are sensitive to project decisions so that they may be used to differentiate the value of alternative project portfolios.

Smart Metrics Decouple Performance Assessment from Project Valuation

A common project prioritization problem is what to do if the magnitude of the benefit available from a project depends on the other projects that are included in the portfolio. Here's an example. The US Department of Energy (DOE) is funding a portfolio of projects designed to increase electricity generation from alternative fuels (fuels other than fossil fuels). With a simple rate-and-weight project
prioritization tool, the DOE could "score" the benefit of, for example, a solar project, but the amount of benefit delivered by the solar project would be less if the project portfolio includes investments in nuclear (because nuclear would likewise increase generating capacity, making the additional incremental capacity from solar less valuable). It seemed that it would be necessary to score various combinations of solar and nuclear investments, but this would be very time consuming and make it difficult to maintain consistency.

The solution is to choose a performance metric that depends only on the project in question. The obvious such metric for this case is the amount of new generating capacity delivered by the project. The value of an increment of new capacity can then be computed based on the total available capacity, accounting for the incremental capacity delivered from all other projects contained in the candidate portfolios. This approach requires that the tool provide the capability to apply non-linear value models and identify the optimal portfolio via optimization (capabilities that simpler tools often lack), but the result is an evaluation approach that requires far fewer and simpler inputs. As illustrated, smart metrics (that is; good modeling practice), often provides a way to address what might otherwise appear to be impossibly complex project interdependencies.

**The Right Metrics Turn Project Proposals into Performance Contracts**

Deriving metrics from a decision model ensures that the organization is seeking the right information about proposed projects; namely, the information necessary to estimate the value to be derived by the organization if the project is conducted. The value of the project can then be compared with its cost, and the resulting “bang for the buck” compared with similar estimates for other candidate projects. This provides a sound basis for making project-selection decisions.

If, in addition, the metrics are observables, the organization further benefits in that project proposals serve as performance contracts. In return for a chance at obtaining a share of the organization’s limited resources, project proponents indicate in the clearest and most relevant terms what they expect the project will accomplish. Project results and impacts can then be tracked and compared with the original estimates. Performance contracts document the terms of the agreement, protecting both parties to the contract. Framing the project as a performance contract creates a healthy shift in perspective. Instead of choosing which projects to cut, the focus is on deciding what project opportunities to purchase.

Due to uncertainty, project outcomes may not exactly match forecasts. Thus, what the implicit contract requires is not that project managers invariably be held responsible for achieving all of the performance indicated by their estimates, but that any significant deviations between estimates and actuals are explained. Over time and on average, some projects should exceed expectations while others will fall short. In the meantime, the organization can learn to improve forecasts by tracking and better understanding the uncertainties that are involved.

In situations where the uncertainty is considerable, it may be useful to separate metrics for indicating the benefits that can be expected from benefits that are more speculative and uncertain. The “expected” benefits then become the basis for the performance contract and the speculative benefits can be appropriately discounted based on risk (see Part 4).
References for Part 3


3. The recommendation to develop a decision model and, more generally, the views and ideas expressed in this and the next part of this paper are shared by many decision analysts. See especially "Choosing the Right Metrics for Measuring, Monitoring, and Maximizing Shareholder Value," C. Spetzler and R. Arnold, www.sdg.com, May 2003. The book *Value Focused Thinking* by R. Keeney describes many of the concepts and techniques for building decision models.


6. Stanford Center for Professional Development, “How Value-Based Management Delivers Vastly Improved Portfolio Results,” Strategic Decision and Risk Management Webinar XSDR001, Stanford University, April 1 2009


8. These quotes were found by searching “strategic alignment” on Google, and were taken from a Project Management Institute project portfolio management seminar brochure, an article entitled “From Crisis to Control: New Standards for Project Management,” and a presentation from a consulting firm. You can find similar statements all over the web.


Inattention to Risk

The economic downturn, terrorism, political upheavals, weather-related disasters, court liability rulings, and other causes are forcing organizations to give risk management more attention. Yet, while nearly all organizations are focusing more on security, quality assurance, liquidity, and insurance, when it comes to selecting projects, many still don't adequately address risk. Inattention to risk is the fourth reason organizations choose the wrong projects.
There are important reasons why more attention to the risks of the project portfolio is needed. The increasingly competitive economic environment is putting ever more pressure on managers to produce results quickly. Meanwhile, projects are becoming more complex due, for example, to new technologies, more regulatory requirements, increased product liability, and the greater dependencies organizations have with external business partners. Finally, uncertainty in world markets and government interventions create external risks that can doom an otherwise sound project.

A 2010 survey of companies practicing project portfolio management identified building risk assessment into project decisions the top strategy for managing project portfolios [1]. The desire to expand portfolio management to include risk management is not surprising, given the vulnerabilities that exist. A serious project mishap, for example, can create significant unforeseen costs, operational failures, regulatory non-compliance with potential penalties, customer dissatisfaction, loss of competitive advantage and market share. Such outcomes may irreversibly damage the reputation and profitability of the organization. Organizations are being held to higher standards by shareholders, customers, regulators, and the public. Executives are much less tolerant of undesired, unexpected project outcomes. Organizations need to better manage risk. Bringing individual projects in on time, on budget, and to project specifications is no longer good enough.

What is Risk?

The first step toward better addressing risk is to understand it. Risk, according to Webster, is "a possibility of loss." Risks arise from uncertainty, our inability to foresee the future. If an uncertainty creates the potential for loss, we refer to it as a risk.

The opportunity to quantify risk is provided by the language of probability. A probability distribution (sometimes called a risk profile) characterizes a risk by describing the range of possible consequences and their probabilities of occurrence, as shown in Figure 25.
Figure 25: Risk is quantified by providing a probability distribution over possible consequences.

Risk is not an additive property—the risk of a portfolio is not the sum or average of the risks of the individual projects within the portfolio. In the case of projects, like financial investments, portfolio risk is determined by the underlying statistical relationships among the uncertainties that contribute. If these underlying statistical relationships are identified and modeled, they can be exploited to find optimal risk-based tradeoffs. Conversely, if they are ignored, large risks may be masked and opportunities to avoid them missed.

Types of Risk

The most common project risks are:

- Cost risk, typically escalation of project costs due to poor cost estimating accuracy and scope creep.
- Schedule risk, the risk that activities will take longer than expected. Slippages in schedule typically increase costs and, also, delays the receipt of project benefits, with a possible loss of competitive advantage.
- Performance risk, the risk that the project will fail to produce results consistent with project specifications.

There are many other types of risks of concern to projects. These risks can result in cost, schedule, or performance problems and create other types of adverse consequences for the organization. For example:

- Governance risk relates to board and management performance with regard to ethics, community stewardship, and company reputation.
- Strategic risks result from errors in strategy, such as choosing a technology that can't be made to work.
- Operational risk includes risks from poor implementation and process problems such as procurement, production, and distribution.
- Market risks include competition, foreign exchange, commodity markets, and interest rate risk, as well as liquidity and credit risks.
- Legal risks arise from legal and regulatory obligations, including contract risks and litigation brought against the organization.
- Risks associated with external hazards, including storms, floods, and earthquakes; vandalism, sabotage, and terrorism; labor strikes; and civil unrest.

As indicated by these examples, project risks include both internal risks associated with successfully completing each stage of the project, plus risks that are beyond the control of the project team. These latter types include external risks that arise from outside the organization but affect the ultimate value to be derived from the project. In all cases, the seriousness of the risk depends on the nature and magnitude of the possible end consequences and their probabilities.

In addition to project risk, project deferral risk can be important. Project deferral risk refers to the risks associated with failing to do a project. Like project risk, project deferral risk can arise from any of the
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bulleted risk sources listed above (the second list). Project deferral risk can also occur if there is only a limited window of opportunity to conduct a project—if the project is not conducted now, there may be a risk that it might never be possible to effectively do it later.

Oftentimes, external risks contribute more to portfolio risk because they impact multiple projects simultaneously. For example, a pharmaceutical company’s R&D project is affected by the uncertain outcomes surrounding the specific compound involved, however many projects could be impacted by a change in regulations. Similarly, a petroleum firm’s exploration project depends on uncertainty over whether oil is present at the given location, but uncertainties over the market price of oil affect many projects. Likewise, a construction company might have many projects threatened by the external risk of an increase in steel or concrete commodity prices.

Methods for Dealing with Risk

A risk that has been identified can be managed using four basic approaches—accept, avoid, transfer, or mitigate. Accepting a risk is the easiest approach for managers, since it requires no further action. Organizations with immature risk management practices often take this course. This is typically due to overconfidence and a failure to appreciate the adverse consequents that would result from the risk event. Also, familiarity plays a role. The better you get to know a risk (especially one that hasn’t yet hurt you), the more accepting of it you become.

Avoiding the risk typically means not undertaking an activity that could carry risk. For example, not engaging in a business that includes the risk of a loss. Although risk avoidance can be a very effective risk management approach, avoiding the source of risk means losing out on the potential gain that accepting the risk may have allowed. Risk avoidance is likewise frequently employed by organizations with less sophisticated risk management, especially as a means for dealing with risks that are less familiar or less well understood.

Risk transfer means transferring the risk to someone else, for example, via contracts or by purchasing insurance. Hedging is another method for transferring risk. For example, a farmer worried about weather might sell a futures contract—a contract to deliver his produce at a fixed price at some time in the future. If the value of the farmer’s crop declines (e.g., due to bad weather), the value of the farmer’s future position will likely go up to offset the loss.

Risk mitigation means reducing the risk, either by reducing the severity of the potential adverse outcome or the likelihood of those outcomes. Safety programs and loss prevention measures such as medical care, fire departments, night security guards, fire sprinkler systems, and burglary alarms are all examples of techniques intended to reduce risks. Risk reduction is often a desirable approach, however, it may not be possible to eliminate all risk. Also, whether or not a risk-reducing alternative is worth doing depends on its cost and effectiveness, and also the organization’s willingness to accept risk.

Project Risk Management

Project risk management has been defined as "an organized assessment and control of project risks." Figure 26 shows the general, 3-step approach to risk management. Step 1 is to identify the risk. Empirical data, recent events, and new regulations (which often signal regulator concern over new risks) are inputs to the risk identification process, and brainstorming and risk scenarios (see below) are examples of techniques that can be used to define and clarify risks. Step 2 is to analyze the risks, which
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means characterizing risk in terms of likelihood and consequences. Step 3 is to manage the risk, taking into account the resources available and the organization’s willingness and ability to accept risk.

Figure 26: The basic steps of risk management.

The appropriate level of detail required for risk management depends, obviously, on the magnitude of risk. Riskier projects, such as new product launches, global initiatives, projects involving new technology, some major regulatory-driven projects, and so forth, tend to have complex interacting elements and involve high stakes. A poor track record on similar projects is an indicator or risk. Likewise, more attention to risk is required when there is project deferral risk. Large deferral risks often occur for organizations responsible for managing systems whose failure might produce serious, large-scale health, safety, environmental or financial consequences (such as a large electric transmission network or an oil refinery). While sophisticated risk management is most needed for the most risky project environments, some level of project risk management should be provided in all cases.

An organization can practice risk management in several different contexts. Projects are proposed throughout the organization in response to perceived needs, threats, and opportunities. Oftentimes, the decision to conduct a project intended to address involves risk. Sometimes, the identified need is itself a risk—the proposed project is to reduce the risk. For example, an organization operating a hazardous facility may invest in projects to reduce health, safety, and environmental risks. In such cases, the project is itself an investment in risk management (in which case there may be project deferral risk).

Regardless of the need or opportunity the project is intended to address, there are three main contexts for project risk management. As shown in Figure 27, these are project planning, project selection, and project execution.
Figure 27: Opportunities for risk management.

Many organizations have instituted risk management processes within project planning and project execution. However, risk management in project selection, as noted earlier, is often little more than a yes/no answer to "Should we accept the risk?" Risk is often viewed as an "intangible" and described using qualitative terms such as "likely" versus "unlikely" and "significant" versus "insignificant." Such words are insufficiently precise and mean different things to different people. For example, a lower-level manager might have a very different notion of what qualifies as a significant risk compared to the CEO. Failure to describe and understand project risk and project deferral risk, coupled with project-by-project decision-making, creates problems for risk management.
Project Selection Risk

Important types of risk are best addressed by project selection because they are outside the scope of project managers. A paper by the accounting firm Ernst & Young provides this example [1]:

A company conducted a project to install new equipment to increase capacity. However, the project planning team failed to evaluate whether the market could absorb the increased supply made available by the added capacity. Narrowly defined, the project was a success because the new equipment was installed successfully, on time and on budget. However, because there was insufficient demand, the company could not sell its extra output at its prevailing price. It ultimately had to shut down some of its production lines.

As illustrated, risk management within project planning and project execution often fails to address external risks. Project portfolio management (ppm) provides an opportunity to account for external risks and to get senior executives to take some ownership of project risks before the project commences. Likewise, including consideration of deferral risk within ppm helps ensure helps ensure that senior executives understand and accept the risks that result from decisions to postpone projects.

Risky Projects May Be Good Projects

Why do organizations tend to decline projects that involve risk? Managers who’ve made bad risk decisions in the past, particularly if they’ve resulted in reputation damage, are unlikely to make decisions that take on risk. Yet, to quote Alan Greenspan, "Risk-taking is indeed a necessary condition for the creation of wealth" [2]. Successful organizations deliberately take risks when it is to their advantage. According to Suzanne Labarge, Vice Chairman of the Royal Bank of Canada, "Risk in itself is not bad. What is bad is risk that is mismanaged, misunderstood, mis-priced, or unintended" [3].

Failure to recognize, understand and accept risk often leads to project portfolios skewed toward low-risk projects with little upside potential. It can also lead to an occasional, unrecognized, high-risk project that endangers the enterprise.

Characterizing Risks

The first step to managing project-selection risk is to identify and characterize the risks associated with doing and not doing projects. Typically, a risk involves a source or cause (e.g., some possible event), a mechanism by which the risk source could impact the objectives of the organization, and some level and type of potential, adverse consequences.

A risk can only be evaluated in relation to the objectives that it impacts. Thus, characterizing risks requires understanding the objectives that are threatened by the risk. Part 3 of this paper argued that the fundamental objectives of organizations are creating shareholder and stakeholder value, and that these overall objectives can only be achieved if certain sub-objectives are achieved. The relevant sub-objectives depend on the organization (as described in Part 3, sub-objectives, along with appropriate metrics, are identified by creating a project decision model). Important objectives typically include some or all of those shown in Figure 28.
Figure 28: (Sub)-objectives (relevant to value creation) that may be impacted by risk.

Figure 28: (Sub)-objectives (relevant to value creation) that may be impacted by risk.

Risks should be identified and documented. Many tools for project portfolio management provide templates for this purpose. A statement of risk should encompass the cause and identify the impact to objectives that might occur. For example, a project cost risk might arise if there is some question about whether the project team has all of the necessary skills for some task. Skills that do not match the job, therefore, is a potential source of risk. Cost, obviously, is the objective potentially impacted. If other objectives might also be impacted (e.g., customer satisfaction) then those objectives should likewise be identified and an explanation provided for how and what sort of impacts might occur. Characterizing the risk includes providing an indication of the nature and magnitude of the potential impact on objectives (e.g., costs could increase by $X, customer Y would be dissatisfied as a result of a two-week delay in obtaining service).

Risks should be characterized using a level of detail sufficient to allow the specific impacts to objectives to be identified and specific actions to address the risk to be evaluated. If the risk is identified and understood, ideas may be generated for modifying the project plan to mitigate the risk. Also, routinely identifying and analyzing project risks generates a database of project risks and associated risk-reducing actions, useful when considering similar projects in the future.

Scenario Building

One of the simplest tools for exploring risk is scenario building (Figure 29), a technique originated by the military. In the context of understanding project-selection risk, scenario building involves hypothesizing plausible events or futures that significantly impact the value or success of a project or set of projects. Envisioning the scenarios as “mental movies” helps to stimulate thinking. Not only does scenario planning help uncover real possibilities, it encourages managers to come up with ways of avoiding potential disasters and ensuring that things turn out reasonably well regardless of which future actually takes place.

Large oil companies have long been users of scenario building. The popularity is often attributed to an early success. In the 1970’s, a planning group at Shell Oil generated scenarios that could affect the price of oil, an uncertainty important to many company projects. One scenario was that prices would remain stable. Another was that OPEC would demand much higher prices. As the latter scenario was developed, it became increasingly clear to the team that the scenario was not just plausible, it was highly likely. However, when the team warned upper management, no changes in company decisions could be observed. So, the team went one step further. They described the logical ramifications of the scenario in terms that leadership would understand: slow growth for the industry and the possibility that OPEC countries would take over Shell’s oil fields. When the Arab oil embargo did occur in 1973, only Shell was reasonably prepared. To manage risks highlighted by the scenario, the company had slowed
refinery expansions and adapted their refineries to better accommodate alternative types of crude oil.

**Figure 29: Scenario building.**

**Qualitative Methods for Addressing Project Risk**

The project risks that remain after project plan based on project risk-management the residual risks that must be considered when selecting projects. For most organizations, factoring risk into project portfolio management involves merely flagging project risks so that they may be considered when decisions to select or reject projects are made. Typically, qualitative methods are used. For example, identified risks might be categorized as high, medium, or low with respect to likelihood and consequence. As shown in Figure 30, this results in a 3x3 risk matrix defining potential responses. Color codes (e.g., green, yellow, and red “traffic lights”) are often used to help summarize risk judgments.

**Figure 30: Risk scoring checklist and risk matrix.**
Qualitative methods may be adequate for screening purposes or in situations where risks are not very serious. The limitation of qualitative methods is that they provide no help for determining the impact of risk on project or portfolio value. In many situations, risk can have a major impact on the value of projects and project portfolios. Using analysis to optimize the project portfolio requires employing quantitative methods to assess and value risk.

**Quantitative Methods for Valuing Risk**

There are two alternative approaches for valuing risk:

1. Compute the decrement (or increment) to the worth of the project caused by project and project-deferral risk.
2. Adjust the discount rate (cost of capital) to reflect the specific level of project risk for each project.

The former approach, which requires that risks be quantified using probabilities, is described in the next two subsections of this paper. The latter approach involves using project hurdle rates. Hurdle rates are simpler, but as explained below, they have serious limitations.

**Be Careful Using Hurdle Rates**

Most organizations that account for risks when valuing projects do so using hurdle rates. The hurdle rate is a risk-adjusted cost of capital used to discount future project costs and benefits. Increased hurdle rates are applied to projects considered to be more risky.

Using hurdle rates may be preferable to ignoring risk or treating it as an intangible. However, hurdle rates have limitations. For one thing, hurdle rates only address project risk, they can’t account for project-deferral risk. Also, organizations are frequently unclear about what hurdle rate should be applied based on project risk. Studies have shown that the rates used by firms vary considerably. According to finance theory, the "correct" hurdle rate is the "opportunity cost" of the investment, which is the return available from investing in securities equivalent to the risk of the project being evaluated. Most companies don't adjust the hurdle rate for risk nearly enough.

A more fundamental problem is reflected in research on real options showing that the discount rate needs to vary with the project management strategy (e.g., an irreversible project investment would call for a higher hurdle rate), as well as with time (the discount rate is not a constant, but changes depending on when the future discounted outcomes are expected to occur), and with changing information. Using a constant hurdle rate for a project implicitly assumes that uncertainty increases over time in a specific way (geometrically). Hurdle rates tend to create a bias toward short-term, quick-payoff projects because they severely penalize project benefits that occur in the longer term.
Characterizing Risks with Probabilities

The best way to understand project risk or project deferral risk is to characterize the risk by describing the range of possible outcomes, estimating when they could occur (risk timing), and assigning probabilities. If relevant data are available (e.g., as might be the case for system failure probabilities for evaluating reliability maintenance projects), probabilities for characterizing risks can be derived using statistical analysis. In the absence of such data, probabilities must still be assigned, and it makes sense to do so directly based on professional judgment.

Although quantifying risks requires more inputs to describe proposed projects, note that the additional inputs need not be very complex. If some aspect of a project's performance is uncertain, instead of obtaining only a middle-value, point estimate, get a range of possible values (e.g., a 90% confidence interval) as well as a mean or most-likely value. (As I described in Part 1, techniques should be used to guard against overly narrow ranges caused by overconfidence.) With practice, it takes no more time to specify a range than it does to generate a single point estimate. The necessary probabilities can be roughly estimated from the range and a mean or most-likely value.

The easiest uncertainties to quantify are those associated with random events whose mean rates of occurrence can be measured, such as weather, accident rates, and commodity prices. Limiting risk quantification in this way, however, can create a sense of lack of urgency. For example, a week before hurricane Katrina struck, New Orleans hosted an offshore-drilling conference that included a panel discussion entitled, “What Has the Industry Learned From Ivan” (Hurricane Ivan had struck the previous September). The lesson was that rigs needed to be much better secured. The industry, however, had not yet made any changes prior to Katrina. The engineering approach to risk assessment told them that hurricanes of this size occur infrequently, which led them to believe that there was plenty of time before the next major storm occurred.

Based on best-professional judgment, probabilities can be assigned to uncertainties for which no frequency data exists. If you can imagine an event, you can assign a probability to it, if not in absolute terms—0.01%, 1%, 10%—then relative to another event whose probability can be measured. (Before you dismiss the predictive value of subjective probabilities, read the section in Part 7 on predictive markets).

Libraries of pre-generated probability distributions can be created to describe commonly encountered risks. For example, Chevron is developing a library of accident probability distributions for analyzing capital investment projects at oil terminals, and Shell has developed a library of distributions for hydrocarbon volumes for oil exploration projects. Generating such probability libraries helps ensure consistency and facilitates auditing the assignments over time. The cover story for an issue of the Journal ORMS Today argued that companies need to consider the prospect of a Chief Probability Officer, someone with the job of managing the probabilities distributions assigned to support project portfolio management [4].
Once probabilities have been assigned, mathematical reasoning can be used to avoid many of the errors and biases described in Part 1 of this paper. For example, you can calculate how the number of observations affects the accuracy of estimates (to avoid small sample bias) and how the conditions required for an event affect the event’s probability (to avoid conjunctive bias). Also, a method known as Bayes’ Theorem can be used to calculate how a probability should be revised or updated as new information becomes available.

The amount of uncertainty caused by project risks and the specific project outcomes that are impacted may be used to better estimate what hurdle rates should be used and the types of benefits to which they should be applied. Quantifying uncertainty also allows more sophisticated methods (such as risk tolerance, explained in the next sub-section of this paper) to be employed to account for risk aversion.

**Project Managers Benefit from Using Probabilities to Describe Uncertainties**

Although project managers may initially feel uncomfortable with probabilities, my experience is that this group can benefit significantly from moving away from using artificial point estimates. The following is a summary of an example devised by Mark Durrenberger of Oak Associates making this point [5].

Imagine that a project manager is asked to complete a project in 3 weeks. Suppose the project manager feels that this estimate is unrealistically optimistic; that everything would have to go just right to make the deadline. The project manager may feel apprehensive about going to the project sponsor to address the problem. It may not be easy to explain why an optimistic, aggressive project schedule isn't a good one.

Suppose, instead, that the project manager estimates as a range the time required to complete each project step. Those ranges can be combined (by adding the means and variances) to determine the probability of completing the effort within any specified time interval. Rather than feeling "at the mercy" of the sponsor, the project manager can now say, "I understand your desire to complete the project within three weeks. However, my calculations suggest that we have less than a 5% chance of meeting that deadline."

The sponsor will want to know more, including how the probability estimate was obtained. This gives the project manager the opportunity to discuss the realities of the job and to negotiate tradeoffs (like providing more resources or eliminating some project deliverables so as to increase the likelihood of meeting the desired schedule).

Note that specifying probability ranges is not a license for a project manager to make baseless claims. Over time, performance can be compared with range estimates. A project manager whose performance routinely beats the means of his specified uncertainty ranges, for example, will be exposed as one who pads estimates.

**Quantifying Uncertainty Over Value**

Importantly, if probabilities have been assigned to the uncertainties associated with key risks, including scenarios, those probabilities can be propagated through the decision model (described in the previous part of this paper) to derive the uncertainty over the various project outcomes and total value of the project. This can be done using Monte Carlo analysis or decision trees.
Monte Carlo analysis is a form of simulation for investigating the uncertain behavior of a physical system. Typically, the system is represented by a mathematical model with uncertain parameters or inputs. The uncertainties are described by probabilities. Monte Carlo analysis involves selecting sets of inputs in accordance with the specified probabilities, executing the model, and recording the model output. Since the specific inputs that are selected for any “trial” are generated randomly (according to the specified probabilities), the process is a little like rolling dice (hence the name). If enough trials are conducted, a frequency plot of the model output shows the shape of the probability distribution over the combined outcome.

By applying Monte Carlo analysis to the project decision model, a probability distribution, or risk profile, can be generated (Figure 31). You can do sensitivity analyses wherein only one die is rolled (only one uncertainty is allowed to vary) while keeping the others fixed. In this way, you can see which uncertainties (risks) have the biggest influence on project value (and focus energies accordingly). The results can be used to investigate changes that might be made to reduce risk. For example, if the distribution says there’s a 50 percent probability the project will run a month late, you might decide to build an extra month into the schedule. Using the decision model and Monte Carlo analysis, you can generate a risk profile for the value of each of your proposed projects.

![Figure 31: Using Monte Carlo analysis to quantify uncertainty in the value delivered by a project.](image)

Decision trees and event trees represent another means for generating probability distributions over project value. Whereas Monte Carlo analysis excels at simulating what happens when many risks and other uncertainties are in play at once, decision trees and event trees are more effective in mapping either-or situations and the sequential uncertainties that follow decisions.

As illustrated by the example in Figure 32, a decision tree is a graphic tree structure composed of decision nodes and chance nodes. The order of the nodes (from left to right) in the tree corresponds to sequence in which uncertain information is anticipated to be revealed and decisions must be made. A decision tree without decision nodes is sometimes called an event tree.
Figure 32: Decision tree for evaluating a project with uncertainty.

Branches emanating from decision nodes correspond to alternatives available at points of decision, and branches from chance nodes represent the possible outcomes to risks and other uncertainties, with associated probabilities.

If the decision model is used to compute a project value corresponding to each path through the tree, the values can be displayed at the tree’s end points (the probabilities of each end point value are the product of the probabilities along the path to the end point). The tree can then be analyzed to determine the risk profile (specifically, by computing a cumulative probability distribution over value by computing the probabilities of all values less than each possible value). Decision trees can also be used to compute a risk-adjusted value for each project, using the method or risk tolerance described later.
An advantage of decision trees and event trees is that they are convenient for exploring how uncertainties evolve over time (as in Figure 33).

![Graph showing annual net revenues over time](image)

**Figure 33:** Characterizing risks shows how uncertainties evolve over time.

### Risks of the Project Portfolio

Another important reason to consider quantifying project risks is that the overall risk of the project portfolio can then be determined. Conducting a portfolio of projects reduces risks through risk diversification (hedging) in the same way that an individual can reduce financial investment risks by investing in a portfolio of diversified stocks. In a stock portfolio there is a limit to how much diversification can reduce risk. This limit is determined by the degree to which stock prices tend to move together; that is, the degree to which the prices of the stocks in the portfolio are statistically dependent or “correlated” with overall market movements. To understand the risks of a stock portfolio, it is necessary to measure these correlations (this is typically done using the correlation statistic called "beta").

In a project portfolio, as illustrated previously, there are risks (e.g., external risks) that impact multiple projects simultaneously. So, in exactly the same way as with stocks, a project portfolio is not as effective at reducing correlated risks. The only way to estimate accurately the risks of alternative project portfolios, and thereby choose projects that collectively produce maximum value at minimum risk, is to quantify these project risks, including statistical dependencies.

Unlike the case for many financial portfolio risks, there is typically no direct way to measure the statistical dependence among the risks of conducting potential projects. However, models can be constructed to represent the relationships. The key is to identify which risks simultaneously affect which projects, and to use the model to appropriately relate the projects to one another.

Failure to account for risks that simultaneously impact numerous investments can have devastating consequences. The 2008 financial crisis provides many illustrations. For example, insurance giant American International Group (AIG) used models to assess the risks associated complicated contracts...
called credit-default swaps, which totaled more than $400 billion. According to an article in the Wall Street Journal, AIG knew their models left out certain market forces and contract terms, but neglected to expand the models [6]. In retrospect, it was clear that the failure to address the common threats caused AIG to vastly underestimate risk and to continue to purchase the dangerous contracts. Were it not for the government bailout, AIG would have collapsed.

Fully characterizing project and project-deferral risks shows whether the assumptions required for using hurdle rates are satisfied and supports the selection of project-specific hurdle rates. It also allows the use of another approach involving the concept of risk tolerance.
Risk Tolerance

An individual’s or company’s aversion to risk taking can be quantified and measured. The concept works as follows. If decision makers did not care about risk, they would want to "go with the odds;" that is, they would want to make decisions so as to maximize expected value. The expected value is defined as the probability-weighted sum of the distribution of possible uncertain outcomes. Decision makers unconcerned about risk would want to maximize expected value because the expected value is the amount that they would obtain on average each time the uncertainty is faced. As an example, the expected value of a coin flip that pays $1 on "heads" and zero on "tails" is 50 cents. If you participated in a thousand such coin flips, your winnings would be very close to $500, so that the average value of each flip would be 50 cents.

For substantial risks, organizations as well as individuals tend to be risk averse, meaning that they value uncertainties at less than their expected values. The "certain equivalent" is defined as the amount of money for which a decision maker would be indifferent between receiving that amount for certain and receiving the distribution of uncertain payoffs represented by the gamble. For example, a risk-averse decision maker might assign a certain equivalent of $500,000 to a risky project with equal chances of yielding $0 and $2,000,000, even though the expected value for this alternative is $1,000,000. Note that this same logic means that a gamble with negative expected value (large downside risk) has a certain equivalent that is even more negative than its expected value (which is why individuals and organizations are willing to pay more in insurance premiums than the expected loss that they are eliminating). The goal of a risk averse decision maker is to maximize the certain equivalent.

For risks with complex payoff distributions, it is generally difficult to determine the certain equivalent. However, the certain equivalent can be estimated for a simple gamble and the results used to infer the certain equivalents of more complicated risks. The approach involves constructing a “utility function” that represents the degree of aversion to taking risks.

Figure 34 illustrates the form (exponential) often chosen for the utility function. The horizontal axis shows possible values or certain equivalents. The vertical axis shows the corresponding “utility,” where utility is a numerical rating assigned to every possible value.

The shape of the utility function determines the degree of aversion to taking risks. The more the plot curves or bends over, the more risk aversion is represented. With the exponential utility function, the degree of curvature is determined by the parameter R, known as the risk tolerance. Thus, risk tolerance is an indicator of a decision maker’s or organization’s willingness to accept risk. Risk tolerance, as defined here, is not the maximum amount that the decision maker can afford to lose, although decision makers and organizations with greater wealth generally have larger risk tolerances.
Figure 34: The exponential utility function is often used to model risk aversion.

Once the risk tolerance is set, the utility function may be used to compute a certain equivalent as follows. First, locate each possible payoff $x$ on the horizontal axis and determine the corresponding utility $U(x)$ on the vertical axis. For example, if risk tolerance is $1$ million and the risk is $50\%$ chance of $0$ or $2$ million, the corresponding utilities (from Figure 10) are $0$ and approximately $0.8$. Second, compute the expected utility by multiplying each utility by its probability and summing the products. For the example, the expected utility is roughly $0.5 \times 0 + 0.5 \times 0.8 = 0.4$. Third, locate the expected utility on the vertical axis and determine the corresponding certain equivalent on the horizontal axis. The result for the example is approximately $500,000$.

There are several ways to determine the risk tolerance for an organization. One is to ask senior decision makers, ideally the CEO, to answer the following hypothetical question. Suppose you have an opportunity to make a risky, but potentially profitable investment. The required investment is an amount $R$ that, for the moment, is unspecified. The investment has a $50\%$ chance of success. If it succeeds, it will generate the full amount invested, including the cost of capital, plus that amount again. In other words, the return will be $R$ if the investment is successful. If the investment fails, half the investment will be lost, so the return is minus $R/2$. Figure 35 illustrates the possible outcomes of the opportunity. As indicated, the expected value of the investment is $R/4$.

Figure 35: What is the maximum amount ($R$) you would accept in this gamble?
If $R$ were very low, most CEOs would want to make the investment. If $R$ were very large, perhaps close to the market value of the enterprise, most CEOs would not take the investment. The risk tolerance is the amount $R$ for which decision makers would just be indifferent between making and not making the investment. In other words, the risk tolerance is the value of $R$ for which the certain equivalent of the investment is zero.

Empirical studies have been conducted to measure organizational risk tolerances. The results show that risk tolerances obtained from different executives within the same organization vary tremendously. Generally, those lower in the organization have lower risk tolerances. As a rough rule of thumb for publicly traded firms, typical risk tolerances at the CEO or Board level are often equal to about 20% of the organization's market value.

Once risk tolerance has been established, the certain equivalent for any risky project or project portfolio can be obtained via the utility function. The effect, as illustrated in Figure 35, is to subtract a risk adjustment factor from the expected value. The risk adjustment factor depends on the risk tolerance and the amount of project risk. If the projects are independent (i.e., their risks are uncorrelated), then the certain equivalent of the project portfolio will be the sum of the certain equivalents of the individual projects. If project risks are correlated, the certain equivalent for the portfolio can be obtained once the distribution of payoffs for the portfolio are computed (accounting for correlations as described above).

![Figure 36: Adjusting project value for risk.](image)

An advantage of this approach is that a single risk tolerance can be established for the organization. Use of the common risk tolerance ensures that risks are treated consistently, thus avoiding the common bias in which greater levels of risk aversion tend to be applied by lower-level managers.

For a demonstration of the importance in the context of project prioritization of addressing risk and risk tolerance, see the Risk Demo at [www.prioritysystem.com/riskdemo.html](http://www.prioritysystem.com/riskdemo.html).
Traditional Analysis vs. Risk Analysis vs. Decision Analysis

Historically, the methods described in this section have most commonly been applied so as to obtain three alternative levels of sophistication for incorporating considerations of risk into project decisions, as summarized in Figure 37. The simplest approach is to use best-, or conservative-estimates for quantitative analysis while treating risk qualitatively. Quantitative risk analysis incorporates uncertainty through the explicit assessment of probabilities. The decision maker not only has probabilistic information about key uncertainties, but also gains knowledge about the uncertainty over project performance. As with traditional analysis, quantitative risk analysis has most often been limited to computing project financial metrics, with non-financial considerations treated as “intangibles,” although as discussed in the previous section this need not be the case. With decision analysis, both non-financial sources of project value and organizational risk tolerance may be incorporated quantitatively into project evaluation.

Figure 37: Three common approaches to risk in project-selection decision making (adapted from [8])
References for Part 4


Inability to Find the Efficient Frontier

The goal for selecting projects is to pick project portfolios that create the greatest possible risk-adjusted value without exceeding the applicable constraint on available resources. Economists call the set of investments that create the greatest possible value at the least possible cost the "efficient frontier." Most organizations fail to find the best project portfolios and, therefore, do not create maximum value. Inability to find the efficient frontier is the fifth reason organizations choose the wrong projects.

If the problems discussed in the previous parts of this series are addressed, value-maximizing project portfolios can be found. Specifically, if the organization is managing the project portfolio, has the right metrics and models in place, including the ability to measure and value risk, and has taken steps to minimize errors and biases in inputs provided to those models, the capability exists to estimate the value that would be created by conducting any proposed project portfolio. It is a relatively easy last step, then, to find the best combination of projects. The concept of the efficient frontier is highly useful in this regard.
The Efficient Frontier

Suppose that an organization plots some of its available project portfolios on a graph relating total value to total cost, as shown in Figure 37. Economists would describe Portfolio A as inefficient because there is another project portfolio, Portfolio B, that produces more value for the same cost. Similarly, there is also a Portfolio C that produces the same value for less cost. Furthermore, there is a Portfolio D with a combination of these two characteristics.

![Figure 37: Different project portfolios have different costs and values.](image)

Now suppose that we consider all of the alternative portfolios that can be constructed from a set of candidate projects. Typically there are many, as suggested by the realistic example of Figure 38. In this case the organization had 30 project proposals under consideration in one budget cycle. Four of those projects were considered mandatory (3 process fixes and a new initiative required by regulators) leaving 26 discretionary projects.
Choosing the Wrong Portfolio of Projects

Part 5: Inability to Find the Efficient Frontier

In general, if there are N potential projects, there are $2^N$ possible project portfolios because there are a total of $2^N$ subsets within a set of N items. (For more explanation see the paper Mathematics: Methods for Solving the Capital Allocation Problem, available on my website). Thus, this application required evaluating $2^{26}$ or approximately 67 million portfolios, far more than shown in Figure 38. The best portfolios define the efficient frontier. Portfolios along the curve at the frontier of the plot are said to be “efficient” because they allow the organization to obtain the greatest possible value from any specified available budget.

**Finding the Frontier**

It is relatively easy for a computer, with an efficient optimization engine, to try various combinations of projects and locate the efficient frontier, provided the right algorithms for calculating portfolio value are in place. Essentially, the optimization is run multiple times, each time with a different specified cost constraint. Even though there may be too many possible portfolios for even the fastest computers to try all combinations, approximate methods are available that can ensure sufficient accuracy for practical purposes. The optimization identifies the highest-value portfolio obtained for each cost, and the result is plotted. The curve obtained in this way defines the efficient frontier (Figure 39).
Choosing the Wrong Portfolio of Projects

Part 5: Inability to Find the Efficient Frontier

Figure 39: The efficient frontier

The Characteristic Curve of the Efficient Frontier

Notice how the efficient frontier is curved, not straight. This is because the frontier is made up of the best possible projects, i.e. those portfolios that show up first on the left side of the curve. Such portfolios create the greatest "bang-for-the-buck," and therefore the curve is steepest here. As the cost constraint is relaxed and more projects can be added, the new projects provide less incremental value compared to those included earlier. The slope of the curve encompassing these projects is flatter because the incremental bang-for-the-buck is not quite as high. Thus, there is a declining return in the value obtained with each additional increment of cost. This is what causes the curve to bend as shown in Figures 39. (As described later, however, the efficient frontier will typically not be completely smooth, but will have some bumps in it.)

The 80/20 Rule

Vilfredo Pareto, an Italian economist, was the first to report what has become recognized as a common rule describing how dissimilar objects are often distributed. Specifically, Pareto observed that approximately 20% of the people owned 80% of the wealth. Since then, a similar relationship has been observed in many other areas, including business contexts, for example, 80% of profits come from 20% of customers, 80% of results come from 20% of the effort, and 80% of the value can be achieved from just 20% of the activities. The relationship is not exact, of course, but it is close in a surprising number of situations. It has become known as the "law of the trivial many and the critical few," or, more simply, as the 80/20 rule.

The curvature of the efficient frontier is such that it often corresponds closely to the 80/20 rule. Roughly 80% of the value available from doing all projects may be achieved by doing just 20% of those projects (assuming, of course, that the best projects are chosen). The lesson is similar to other instances where the rule applies—Managers should concentrate on identifying and doing the few things that are critical rather than wasting effort on the many things whose impacts are trivial.
The Efficient Frontier Depends on the Quality and Quantity of Project Options

The efficient frontier improves if project alternatives improve. Figure 40 shows what happened when project proponents were asked to submit 3 alternative versions for each project proposal (the original or base-version proposal, a minimum cost - reduced scope version, and an enhanced cost - enhanced scope version).

![Figure 40: More (and better) project options improve the efficient frontier](image)

Additional project options allow better project portfolios to be constructed. Thus, the efficient frontier moved up and to the left. By adjusting the spending levels for projects, portfolio value was increased by 14%.

The Efficient Frontier Moves over Time

Regardless of the number of project alternatives analyzed, the efficient frontier tends to improve over time. Organizations continually face the challenge of identifying investment opportunities and finding project alternatives that advance the frontier. As project managers better understand the link between their project designs and the value derived by the organization, they create better project proposals. Also, better technology creates new opportunities that create more value for less cost. This causes the efficient frontier to move up. The fundamental goal, though, remains the same—create as much value as possible using as little capital as possible. To do this, you must find the efficient frontier.
**Efficient Frontiers versus Ranking Curves**

As indicated in the previous section, generating the efficient frontier requires a software tool with an optimization engine; that is, the ability to solve mathematical optimization problems with constraints. Many project portfolio management tools lack optimization engines and therefore lack the ability to generate efficient frontiers. As an alternative, such tools often create a graph that looks similar to an efficient frontier—they rank projects based on the ratio of project value (or some measure related to project value) to project cost and then plot cumulative value versus cumulative cost while adding projects to the portfolio in rank order. Although many authors erroneously refer to the result as the efficient frontier, it is more accurately referred to as a ranking (or productivity ranking) curve.

The reason that the efficient frontier and a ranking curve are often confused is due to the fact that there is an important special case for which the two curves will be very nearly the same. In particular, if projects are independent and risks are either independent or do not matter, the costs and value of the project portfolio are basically just sums of the costs and values of the individual projects that make up the portfolio. In this case, the value-maximizing portfolios can be obtained by ranking projects based on the ratio of project value to project cost, and the efficient frontier can be plotted by adding projects to the portfolio in the order of benefit-to-cost ratios. Figure 41 illustrates.

![Figure 41: A project ranking curve.](image)

Although ranking produces portfolios on the efficient frontier for the special case where the choice is among independent projects, in general the curve produced by ranking projects will not be the efficient frontier. As explained below, there are several reasons for this difference.
The Ranking Curve Misses Opportunities to Use Unspent Budget

At best, a ranking curve will only match the efficient frontier at precisely the cumulative budget levels that result when projects are added to the portfolio in rank order. Ranking fails to identify the portfolios on the efficient frontier that lie between these points (e.g., the portfolio colored red in Figure 42).

The yellow points in Figure 42 represent portfolios constructed by ranking. If the budget is A, the remaining funds are insufficient to include Project e, so Project d is the last project added to the portfolio. An optimization engine is needed to identify a better project combination (e.g., the portfolio designated by the red point) that comes closer to using the total budget. Such portfolios create more value, typically by replacing one or more higher ranked projects by a combination of lower ranked projects so as to use a greater fraction of the available budget. The error inherent in using the ranking curve rather than the efficient frontier tends to be more significant the more available projects differ in cost.

The Ranking Curve Misses Opportunities to Adjust Project Funding Based on Available Budget

As shown previously, providing multiple versions of proposed projects (i.e., different levels of project effectiveness based on different project scopes, approaches, etc.) can significantly shift the efficient frontier. Two versions of the same project are not independent project options. For example, if you choose a low-cost version of a project, that decision would obviously reduce the attractiveness of simultaneously funding a higher-cost version of the same project. This violates the basic requirement for ranking, meaning that a simple ranking approach cannot be used to approximate the efficient frontier when there are multiple project options available. Optimization is needed to select project versions that together best utilize the available budget.
Choosing the Wrong Portfolio of Projects
Part 5: Inability to Find the Efficient Frontier

Because adjusting project funding is often a better option than the all-or-nothing choice implied by project ranking, the efficient frontier generally lies above the ranking curve if there are multiple versions available for projects. Figure 43 provides an illustrative example. In this case, 3 versions are assumed to be available for each project, a low-cost, mid-cost, and high-cost version. Project benefits are assumed to increase with project costs, and the project costs and the incremental costs of moving to more expensive project versions are assumed to be the same for all projects. These assumptions ensure that the efficient frontier will have the sort of smooth curve that is shown in the figure. Notice that higher budgets result in more expensive project versions being selected.

![Figure 43: The efficient frontier varies project funding to increase portfolio value (illustrative data).](image-url)
The Ranking Curve Fails to Account for Multiple Resource Constraints

A major limitation of the ranking curve compared to the efficient frontier is that the ranking curve cannot account for constraints other than the funding constraint. Only a single cost constraint can be addressed through the ranking approach. If, for example, some projects require funding over multiple budget cycles, the constraints that may exist on funding for the various years cannot be addressed. Furthermore, in such cases, it is not entirely clear, when ranking projects based on the ratio of benefits to costs, what cost should be used in the denominator and what benefits should be used in the numerator. For example, should projects be ranked based on the ratio of total benefit (the benefit generated if the project continues to be funded until completion) to total cost (including the remaining, out-year costs required to secure those benefits)? Or, should projects be ranked based the ratio of total benefits less remaining costs to budget year costs? Or, should projects be ranked based on budget year benefits (the portion of benefits that are attributed to budget-year spending) to budget-year costs? Each approach will yield a different ranking.

With the efficient frontier, additional constraints can be established for the optimization. Thus, for example, the optimization engine can be used to generate efficient frontiers that show the value maximizing project portfolios under alternative budget-year costs subject to various specified constraints on out-year funding as well as subject to constraints on people and other resources needed for projects. Establishing additional constraints to be achieved by the resource allocation will change project recommendations (to ensure that the constraints are met), which will tend to lower the efficient frontier. A simple ranking curve cannot under these circumstances identify the optimal project portfolios.
A Real Efficient Frontier

Real efficient frontiers tend to be more complex than the simple examples above. To illustrate, the business units within an organization proposed a total of 30 projects. Budget-year costs ranged from $40,000 to over $8 million. Some of the larger projects were multiyear in duration, and about a third of the projects were proposed in multiple versions (e.g., low cost, base, and enhanced versions). If all projects were funded (with multi-version projects funded at their highest funding levels), a total budget of roughly $33 million would be required. The organization’s target budget was $17 million. Obviously, prioritization was necessary.

Figure 44 shows the efficient frontier, and Figure 45 shows how the projects included in the portfolios on the frontier depend on the total budget. Although the efficient frontier bends over in the typical fashion, there are the bumps in the curve. The labels in Figure 45 are unreadable, but what is important is the pattern.

Figure 44: A real efficient frontier.
Figure 45: Optimal funding decisions for budgets between $1 M and $35 M in $1 M increments.

As in the previous simplified example, the rows in the table of Figure 45 correspond to projects and the columns (left to right) represent increasing funding levels. The colors in the cells indicate funding recommendations, with darker cells indicating recommendations to fund more expensive project versions. Although an increase in the budget is generally associated with an increase in funding for some project, sometimes increasing the budget causes the funding recommendation for a project to be reduced. This is typical behavior for real efficient frontiers.

The bumps in the efficient frontier are caused when the optimization engine identifies opportunities for moving projects into and out of the portfolio in ways that significantly increase total value. To take a dramatic example, notice the “jump” in the curve that occurs for a budget just above $5 million. The cause of the jump is a high-cost project with a minimum spending level of $5.05 million (it is the project in the 5th row in the table in Figure 45). At this spending level, the project provides a relatively high benefit-to-cost ratio of 8.78.

Figure 46 shows the detailed portion of the funding table corresponding to budgets near $5 million (the increments in this table are $25,000 per column, compared to $1 million in the previous table). If the total budget is less than $5.05 million, then, obviously, the $5.05 million project cannot be accommodated. However, when the budget hits 5.05 million, all of the smaller projects that were funded earlier are eliminated from the portfolio, which frees the entire budget to fund this one high-value project and results in the jump in the curve (an increase in portfolio value of $8.62 million!).
Choosing the Wrong Portfolio of Projects

Part 5: Inability to Find the Efficient Frontier

Figure 46: Optimal funding decisions for budgets between $5 M and $5.1 M in $25 K increments

Although large jumps in the efficient frontier often occur at highly constrained budgets, such jumps are not of practical significance unless they occur near the organization’s actual budget constraint (which typically happens when there are high-cost projects with high benefit-to-cost ratios that are in danger of not being funded). In such situations, the efficient frontier can identify opportunities for small increases in the total budget that could produce relatively large increases in total value.
Importance of the Efficient Frontier

Suppose we construct the efficient frontier as described in the previous sections. The result is useful for several reasons.

The Efficient Frontier Answers Key Questions

The efficient frontier allows us to answer four important questions:

1. What are the best project choices given a specified constraint on the available budget and/or other resources?
2. If, for political or other reasons, we choose a specific, non-optimal set of projects (a project set not on the efficient frontier), by how much are we over-spending and how much potentially achievable value are we losing?
3. Based on the total value obtained for the total dollars spent, are we over- or under-spending on projects?
4. How should we allocate the total budget across organizational units or to different types of projects?

The best project choices (Question 1) are, of course, those contained in the portfolio that lies on the efficient frontier at the cost level at, or just below, the cost constraint. The losses resulting from choosing a non-optimal portfolio (Question 2) are the horizontal and vertical distances from the selected portfolio to the efficient frontier (see Figure 48 below). With regard to Question 3, an organization is overspending on projects if the chosen portfolio lies on that portion of the curve where the slope is less than 1.

Question 4, how to allocate resources among organizational units can be answered if a separate efficient frontier is constructed for the projects proposed by each business unit. As shown in Figure 47, the optimal allocation funds portfolios on the respective curves where the slopes are equal. This result provides a useful approach for developing tiered priority systems for organizations with decentralized project prioritization processes.
Evidence that Finding the Efficient Frontier Adds Considerable Value

In real-world applications, it is sometimes possible to compare the performance of a current portfolio with optimal portfolios that are on the efficient frontier. Figure 48, derived from an actual application, shows that an alternative portfolio was found that increased value by over 30% without increasing costs. Similarly, an alternative portfolio was found that reduced costs by 40% without decreasing value. This result is typical for organizations conducting projects that are difficult to value. Application of the efficient frontier approach shows that current project portfolios are often well below their potential.
Better project portfolios are not the only benefit of the efficient frontier. Calculating the efficient frontier creates a new perspective, one that helps managers throughout the organization to fully appreciate the reality that resources are limited, to better understand the relationship between value created and costs incurred, and, when the opportunity is great enough, to find ways to break the constraint on costs.

Figure 48: Project portfolio enhanced by applying the efficient frontier.
Achieving Best-Practice

Project portfolio management is a tool-supported process for effectively organizing and managing the multi-project environment. It is an ongoing, dynamic process wherein projects and project proposals are regularly evaluated, prioritized, and selected based on the goal of obtaining the greatest possible value from the available limited resources. Making the best project choices is the core of project portfolio management, but project selection includes deciding how to allocate and apply resources to projects, project timing, and when to accelerate, slow, or kill projects.

Almost any project selection process will separate "must-do" projects from clear "losers." How far organizations go beyond this depends on the effort they put into it. In order to get much beyond a "60% solution," however, organizations need to address the fundamental reasons that organizations choose the wrong projects.
Address the Reasons Organizations Choose the Wrong Projects

In summary, organizations need to:

✓ **Address the errors and biases that affect human judgment.**
  - Increase awareness of prevalent errors and biases, including comfort zone, perception, and motivation biases, as well as errors in reasoning, and "group think." As Daniel Kahneman advises, use the knowledge to create "human error detectors" within your organization.
  - Consider incentives and the effects of framing when evaluating your own and other people's judgments. Remember that an estimate from a disinterested but knowledgeable party may be more reliable than that of a better-informed but involved expert.
  - Provide feedback to people on the accuracy of their forecasts. Require that forecasts of project performance be expressed in terms of observables that pass the clairvoyant test. Then, collect data from funded projects to help calibrate people and keep their estimates honest.

✓ **Get control of the project-selection process.**
  - See the forest as well as the trees. Collect projects and project proposals into a common database. Look for duplications and interdependencies. Establish common format and content requirements for project proposals.
  - Insist on due diligence for project investments. This means that spending choices must be based on documented consideration of the business consequences of doing versus not doing the project.
  - Move from project-by-project decision-making to decision-making aimed at producing optimal project portfolios. Create a project portfolio management office with responsibility for managing the organization's portfolio of projects.
  - Expose hidden discretionary spending (e.g., “mandatory” projects that could be delayed, done with reduced scope, “miscellaneous” spending)
  - Adopt a systems perspective that explores the chain of consequences produced by the choices that may be made. Understand the options that are created and destroyed by project choices.
  - Understand and measure how project investments translate into business performance (e.g., service, reliability, efficiency, and productivity).

✓ **Make Value Creation the Organizational Goal.**
  - Promote a culture focused on creating the greatest possible value for the organization. Value creation is a compelling argument, one that can overcome inertia and the barriers against positive change.
  - Create a project-selection decision model for your business that documents best-organizational understanding about how projects create value.
  - Use the decision model to select performance measures for systematically evaluating proposed projects.
  - Engage senior executives in the process of establishing objectives, defining how value
tradeoffs should be made, sharing ownership of project decisions, and co-developing project expectations.

- Understand and measure how performance impacts translate into economic (e.g., shareholder/stakeholder) value within businesses and across the enterprise.
- When choosing projects, consider project urgency as well as project value.

✔ Be proactive in addressing risk.

- Create a culture that insists on facing up to risk. Accept the fact that the world is volatile, that things are changing rapidly, and that bad things might happen.
- Establish processes for identifying internal and external project and project-deferral risks. Assess those risks and communicate them. Implement risk-mitigation action plans.
- Think in terms of probabilities. Don’t just ask what might happen. Ask how likely it is.
- Avoid the bias toward doing too many, mostly low-risk, low-return projects. Remember that risky projects often create learning and increased capability, values that aren't readily captured in financial metrics.
- For "big bet" investments, quantify risks and consider establishing an organizational risk tolerance to guide decision-making.

✔ Build decision-making competencies.

- Empower decision makers. The old command-and-control structure no longer works. It is too slow and creates information overload for leaders.
- Remove barriers to the free flow of information. If people hoard information as a source of power, others can’t make informed choices.
- Promote and attend training workshops on the principles and techniques of decision analysis, project prioritization, and project portfolio management.
- Learn the best techniques for articulating objectives, expressing value tradeoffs, assessing probabilities, and establishing risk tolerance.
- Recognize and reward people based on the quality of their decisions, not just based on the quality of their outcomes.

✔ Be smart about institutionalizing new tools.

- Start at the top and generate executive buy-in. Leaders must be visible champions for change. Create awareness, build consensus, and motivate stakeholders at all levels.
- Involve stakeholders in the design, testing, and roll-out of new tools. Establish formal agreements on roles and responsibilities across the organization. Provide training and support appropriate to people’s roles.
- Don’t overwhelm the organization. Match the pace of change to the organization’s capacity to evolve. A gradual roll-out based on proof-of-concept is usually more successful. Use gap analysis to target the initial application on a critical need. Publicize successes throughout the organization.
- Develop the governance process. Organizational structure that supports project portfolio management is essential.
Five Levels of Project Portfolio Management

Figure 49 summarizes five levels of project portfolio management maturity [1]. Each level represents the adoption of an increasingly comprehensive and effective subsets of related solutions discussed in the previous parts of this 6-part paper for addressing the reasons that organizations choose the wrong projects. Understanding organizational maturity with regard to project portfolio management is useful. It facilitates identifying performance gaps, indicates reasonable performance targets, and suggests an achievable path for improvement.

The fact that five maturity levels have been identified is not meant to suggest that all organizations ought to strive for top-level performance. Each organization needs to determine what level of performance is reasonable at the current time based on business needs, resources available to engineer change, and organizational ability to accept change.

The detailed definitions of the levels, provided below, are not precise. Real organizations will tend to be more advanced with regard to some characteristics and less advanced relative to others. For most organizations, though, it is easy to identify one of the levels as roughly characterizing the current maturity of project portfolio management.

![Figure 49: Five levels of project portfolio management.](image-url)
Level 1: Foundation

Level 1 organizes work into discrete projects and tracks costs at the project level.

- Project decisions are made project-by-project without adherence to formal project selection criteria.
- The portfolio concept may be recognized, but portfolio data are not centrally managed and/or not regularly refreshed.
- Roles and responsibilities have not been defined or are generic, and no value-creation framework has been established.
- Only rarely are business case analyses conducted for projects, and the quality is often poor.
- Project proposals reference business benefits generally, but estimates are nearly always qualitative rather than quantitative.
- There is little or no formal balancing between the supply and demand for project resources, and there is little if any coordination of resources across projects, which often results in resource conflicts.
- Over-commitment of resources is common.
- There may be a growing recognition that risks need to be managed, but there is little real management of risk.

Under Level 1, projects are viewed and managed in isolation of one another, subject only to the competition over shared resources. Projects are funded separately, reviewed separately, and hardly ever terminated for reasons other than excessive cost and duration overrun. Projects are managed reactively as problems or opportunities are identified.

Although, Level 1 organizations are not yet benefiting from PPM, they may recognize the inherent problems and be motivated to address those problems. If so, they have the minimum foundation in place to begin building PPM capability. In order to be ready to move to Level 2, organizations should focus on establishing consistent, repeatable processes for project scheduling, resource assignment, time tracking, project tracking, and general project oversight and support. In order to facilitate project decisionmaking, projects should be consistently defined to include all of the efforts necessary to secure the benefits that motivate the work, with project work broken into activities and tasks as necessary to facilitate planning. Costs should be tracked at the project level, and project proposals should be supported by clear statements of the need and presumed project benefits.

Level 2: Basics

Level 2 replaces project-by-project decision making with the goal of identifying the best collection of projects to be conducted within the resources available. At a minimum this requires aggregating project data into a central database, assigning responsibilities for project portfolio management, and force-ranking projects.

- Redundant projects are identified and eliminated or merged.
- Business cases are conducted for larger projects, although quality may be inconsistent.
- Individual departments may be establishing structures to oversee and coordinate their projects.
Choosing the Wrong Portfolio of Projects

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- There is some degree of options analysis (i.e., different versions of the project will be considered).
- Project selection criteria are explicitly defined, but the link to value creation is sketchy.
- Planning is mostly activity scheduling with limited performance forecasting.
- There are attempts to quantify some non-financial benefits, but estimates are mostly “guestimates” generated without the aid of standard techniques.
- Overlap and double counting of benefits between projects is common.
- Ongoing projects are still rarely terminated based on poor performance.
- Project interrelationships are recognized from a technical perspective, with inter-related projects organized into and managed as programs.
- If PPM tools are being used, the tools are likely to provide useful project data rollup, but project prioritization algorithms are typically simplistic and may produce results potentially misleading to decision makers.
- Portfolio data has an established refresh cycle or is regularly accessed and updated. Resource requirements at the portfolio level are recognized but not systematically managed.
- Knowledge sharing is local and ad hoc.
- Risk analysis may be conducted early in projects but is not maintained as a continual management process. Uncertainties in project schedule, cost and benefits are not quantified.
- Schedule and cost overruns are still common, and the risks of project failure remain large.

Level 2 organizations are beginning to implement elements of project portfolio management, but only a fraction of the real opportunity has been realized. If a formalized PPM unit exists, it is likely modest and not very sophisticated. Even so, prioritization, probably without much reliance on prioritization tools, is used as a means for addressing the problem of too many projects given the limits on available resources. At this stage, the focus should be on formalizing the framework for evaluating and prioritizing projects and on implementing tools and processes for improving project budgeting, cost accounting, risk and issues tracking, requirements tracking, and resource management.

**Level 3: Value Management**

Level 3, the most difficult step for most organizations, requires metrics, models, and tools for quantifying the value to be derived from projects. Although project interdependencies and portfolio risks may not be fully and rigorously addressed, analysis allows projects to be ranked based on "bang-for-the-buck," often producing a good approximation of the value-maximizing project portfolio

- The principles of portfolio management are widely understood and accepted.
- The project portfolio has a well-defined perimeter, with clear demarcation and understanding of what it contains and does not contain.
- Portfolio management processes are centrally defined and well documented, as are roles and responsibility for governance and delivery.
Portfolio management can demonstrate that its role in scrutinizing projects has resulted in some initiatives being stopped or reshaped to increase portfolio value.

Executives are engaged, provide tradeoff weights for the value model, and provide active and informed support.

Plans are developed to a consistent standard and are outcome- or value-based.

Effective estimation techniques are being used within planning and a range of project alternatives are routinely considered.

Data quality assurance processes are in place and independent reviews are conducted.

There is a common, consistent practice for project approval and monitoring.

Project dependencies are identified, tracked, and managed.

Decisions are made with the aid of a tool based on a defensible logic for computing project value that generates the efficient frontier.

Portfolio data are kept up-to-date and audit trails are maintained.

Costs, expenditures and forecasts are monitored at the portfolio level in accordance with established guidelines and procedures.

Interfaces with financial and other related functions within the organization have been defined.

A process is in place for validating the realization of project benefits.

There is a defined risk analysis and management process, with efforts appropriate to risk significance, although some sources of risk are not quantified in terms of probability and consequence.

Level 3 organizations demonstrate a commitment to proactive, standardized project and portfolio management. Project selection decisions are based on an overarching principle of creating value, with all projects evaluated and re-evaluated together using a consistent and defensible logic. A PPM unit manages the project portfolio. Participants have a high-level of applicable training. Level 3 organizations are achieving significant return from their investment, although more value is available.

**Level 4: Optimization**

Level 4 is characterized by mature processes, superior analytics, and quantitatively managed behavior.

- Tools for optimizing the project portfolio correctly and fully account for project risks and interdependencies.
- The business processes of value creation have been modeled and measurement data is collected to validate and refine the model.
- The model is the basis for the logic for estimating project value, prioritizing projects, making project funding and resource allocation decisions, and optimizing the project portfolio.
- The organization’s tolerance for risk is known, and used to guide decisions that determine the balance of risk and benefit across the portfolio.
There is clear accountability and ownership of risks.

External risks are monitored and evaluated as part of the investment management process and common risks across the whole portfolio (which may not be visible to individual projects) are quantified and in support of portfolio optimization.

Senior executives are committed, engaged, and proactively seek out innovative ways to increase value.

There is likely to be an established training program to develop the skills and knowledge of individuals so that they can more readily perform their designated roles.

An extensive range of communications channels and techniques are used for collaboration and stakeholder management.

High-level reports on key aspects of portfolio are regularly delivered to executives and the information is used to inform strategic decision making.

There is trend reporting on progress, actual and projected cost, value, and level of risk.

Assessments of stakeholder confidence are collected and used for process improvement.

Portfolio data is current and extensively referenced for better decision making.

Level 4 organizations are using quantitative analysis and measurements to obtain efficient, predictable, and controllable project and portfolio management. The organizations various portfolio are rolled up into one, all-inclusive portfolio, with portfolio optimization used to coordinate and manage the individual portfolios. Level 4 organizations are obtaining the bulk of the value available from practicing PPM.

**Level 5: Core Competency**

Level 5 occurs when the organization has made project portfolio management a core competency, uses best-practice analytic tools, and has put processes in place for continuous learning and improvement.

- Portfolio management processes are proven and project decisions, including project funding levels and timing, are routinely made based on the value maximization value.
- Processes are continually refined to take into account increasing knowledge, changing business needs, and external factors.
- Portfolio management drives the planning, development, and allocation of projects to optimize the efficient use of resources in achieving the strategic objectives of the organization.
- High levels of competence are embedded in all portfolio management roles, and portfolio management skills are seen as important for career advancement.
- Portfolio gate reviews are used to proactively assess and manage portfolio value and risk.
- Portfolio management informs future capacity demands, capability requirements are recognized, and resource levels are strategically managed.
- Information is highly valued, and the organization’s ability to mitigate external risks and grasp opportunities is enhanced by identifying innovative ways to acquire and better share...
knowledge.

- Benefits management processes are embedded across the organization, with benefits realization explicitly aligned with the value measurement framework.
- The portfolio is actively managed to ensure the long term sustainability of the enterprise.
- Stakeholder engagement is embedded in the organization’s culture, and stakeholder management processes have been optimized.
- Risk management underpins decision-making throughout the organization.
- Quantitatively measurable goals for process improvement have been established and performance against them tracked.
- The relationship between the portfolio and strategic planning is understood and managed.
- Resource allocations to and from projects are intimately aligned so as to maximize value creation.

Level 5 organizations are obtaining maximum possible value from project portfolio management. The PPM unit is running at maximum efficiency. By fully institutionalizing project portfolio management into their culture, Level 5 organizations free people to become more creative and innovative in achieving business success.

**Building Project Portfolio Management Maturity**

Experience shows that building project portfolio management maturity takes time. As suggested by Figure 50, significant short-term performance gains can be achieved, but making step changes requires understanding current weaknesses and the commitment of effort and resources.

![Figure 50: Step changes can be made, but achieving high levels of maturity typically takes years.](image)

According to the PM Solutions Research 2013 State of PPM Survey, 43% of Level 1 Capable...
organizations have had a PPM process in place less than six months, while 71% of Level 5 Capable organizations have had a PPM process in place more than five years [2].
Best-Practice Project Portfolio Management

Although the specifics of project portfolio management necessarily differ from organization to organization, the fundamentals of best practice are nearly universal. Project portfolio management is an ongoing activity, not just an annual event. It is driven by the fundamental objectives the organization, and it demands and enables broad organizational involvement. The goal in all cases is to select and manage project portfolios so as to create the greatest possible value for the organization.

Organizations that have achieved best practice have a clear understanding of the value creation process. They have identified and structured their objectives and have established metrics for forecasting and tracking the degree to which they achieve those objectives. They use a project-selection decision model to evaluate project proposals, and update and refine that model as their knowledge and understanding improves.

The model allows them to estimate the impact on the business of doing versus no doing individual projects as well as conducting various combinations of interdependent projects. The project consequences estimated include not only impacts on financial performance, such as future cost savings and increases in revenue, but also include non-financial impacts, such as improved customer service and organizational learning. Best-practice organizations translate these performance impacts into equivalent monetary value based on the worth of the project benefits to the organization. Project risks are addressed, including both project risk and project deferral risk. Portfolio-level risks are likewise understood, quantified, and managed.

The project portfolio management process is supported by a quality software tool with smart, template-driven data collection and flexible graphic and reporting capabilities. The tool has a project dashboard that quickly provides portfolio summary information with easy drill down to single-page project reports. Value-maximizing project portfolios can be identified with capability for “what if” and sensitivity analysis. The tool serves as a useful and used aid within the decision making process. Project priorities and ultimate project decisions are conveyed to all stakeholders. The outcomes of project decisions are monitored, and there is a significant focus on mining experience and identifying opportunities for improvement.

Participants

The table on the next page identifies the key players and responsibilities.
Choosing the Wrong Portfolio of Projects

Part 6: Achieving Best-Practice

<table>
<thead>
<tr>
<th>Business Unit/Sponsor</th>
<th>Project Manager</th>
<th>Project Portfolio Manager</th>
<th>Executive Team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any organizational component that requests or consumes a portion of the budget for the purpose of conducting projects.</td>
<td>Individual with overall responsibility for successful planning and execution of a project.</td>
<td>Manager with responsibility for the project portfolio. Usually supported by a team. Team may be composed of directors of the business areas.</td>
<td>Select corporate officers who guide and provide inputs to the project portfolio management process.</td>
</tr>
<tr>
<td>Each business unit identifies projects, assists project managers in constructing business cases for justifying projects, and champions its projects and project portfolio. The business unit is responsible for providing quality assurance for data related to its projects.</td>
<td>Project managers work closely with business units/sponsors to provide good data for the portfolio management process. Project managers are responsible for ensuring that approved projects perform according to plan.</td>
<td>The project portfolio manager establishes the rules, and procedures for making portfolio decisions. The portfolio manager analyses projects and portfolios proposed by business units and recommends the overall project portfolio.</td>
<td>The executive team provides policy inputs for the process, including weights for trading off different types of project benefits. The team sets targets, approves the budget and project portfolios, and ensures that portfolio decisions are enforced.</td>
</tr>
</tbody>
</table>

Phases

The three phases of the project portfolio management cycle are preparation, execution, and performance management. Figure 51 shows the typical process timeline and Figure 52 provides more detail on typical process flows.

![Figure 51: Typical project portfolio management process timeline.](image-url)
Figure 52: Process flow diagram for project portfolio management.
Preparation

A calendar is established and responsibilities are assigned. Corporate executives set high-level strategy. The executive team establishes financial and performance targets for each business unit and provides guidelines and a schedule for completing the budgeting process. With the assistance of the portfolio manager, the team establishes basic assumptions for analysis (including value weights, discount rates, and risk tolerance).

Execution

Within each business unit, projects are identified, classified, and appropriately grouped. Alternative project solutions are explored. Decision units for each project are defined (e.g., go vs. no-go, alternative project solutions, alternative funding levels and scopes for the preferred project solution). Project descriptions are documented, including timelines, resource needs, etc., and project proposal templates generated by the tool are completed. Technical analyses are conducted to estimate the impacts of each project or project grouping on the achievement of corporate and business unit objectives (using external models or the models inherent in the tool). Financial analyses are similarly conducted. Risks are identified and described. With the aid of the tool, project and portfolio values are estimated and the projects within each business unit are prioritized. Based on the results, project plans are revised. Business unit priorities are established and feed corporate-level prioritizations and the allocation of resources across business units. A value prioritized budget is established and spending approvals are granted.

Performance Management

A performance management plan monitors and manages the success of the project portfolio. The plan specifies project performance indicators that allow comparing forecast and actual performance, plus monitoring and reporting schedules. Project shortfalls are analyzed, including causes, approaches for correcting variances, and decisions for ongoing investments. Lessons learned are derived and the project portfolio management process is refined prior to the next budget cycle.

Iterative Nature

Although Figure 52 presents PPM as being conducted in a series of phases, the process is really better thought of as cyclical and iterative in nature. As shown by the arrows in the diagram, an outcome at one step in a phase can result in the re-execution of other steps in that phase. For example, in the Execution phase, an unexpected result from the PPM tool (e.g., unexpected priority) can prompt a review and subsequent correction of poor estimates or errors in project data. Also, outcomes in one phase can result in activities in previous phases to being repeated. For example, revisions to data might be made immediately based on learnings from the Implementation phase. External factors may also cause the process to iterate. For example, changes in the business environment might produce a change in organizational strategy, which would likely change weights or other assumptions important to the analysis. A key advantage of having a well-defined process supported by a quality PPM tool is the ability quickly adjust to internal and external events and to translate such understanding into portfolio decisions. Iteration is important for real-time information exchange and the dynamic management of the project portfolio.
Why Isn't Everyone Doing this Already?

As this paper has described, methods are available for addressing all of the reasons organizations choose the wrong projects, including quantitative methods for identifying projects on the efficient frontier. Some organizations that regularly make high-stakes, project-selection decisions (e.g. some financial institutions, oil and gas exploration companies, pharmaceutical companies, some high-tech companies, the military and some other government agencies) are already using sophisticated versions of these methods. But, most organizations are not. A fair question is, "If what you’ve described is so great, why isn't everybody already doing it?"

One practical reason why relatively few organizations are using these techniques is that the relevant models and mathematical operations require sophisticated computer operations. It is only recently that high-powered computer capability has become widely available, and more recent still that managers have begun to feel comfortable using computers directly in support of their work.

In some organizations, resistance to formal, analytic methods may be politically motivated. Some executives may fear any change that threatens the power systems they have worked long and hard to create. A system that causes decisions to be based more on fact and reason will mean that political pressures and false urgencies will be less effective tools for steering the organization. From the personal perspective of a politically savvy executive, particularly one that believes he or she is more able than others to discern what is best for the organization, it may make perfect sense to resist attempts to adopt analytic methods.

Most organizations, however, are under increasing pressure to find ways to do more with their limited resources, and many managers are facing growing demands to explain the basis for their decisions. Thus, it would seem increasingly unlikely that a few self-serving individuals could successfully discourage their organizations from adopting proven analytic solutions. Yet many organizations continue to be slow in adopting best-practice methods. There must be more fundamental reasons that explain the resistance. Indeed, if what I’ve said in this paper is true—that organizations may be obtaining only 60% of the value that could be derived from using best-practice project portfolio management—the barriers to adopting such methods must be significant.

I believe that there are 5 impediments that cause people to resist best-practice analytic methods (Figure 53): (1) the prevalence of misinformation, (2) the fact that leaders may take misplaced pride in being intuitive decision makers, (3) fear of complexity, (4) a belief that there may be too much uncertainty to justify sophisticated methods, and (5) under appreciation of the predictive power of judgment. Understanding these barriers can help you to develop effective strategies for bringing best practice methods into your organization.
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Prevalence of Misinformation

In a recent article, Jeffrey Pfeffer and Robert Sutton address the question of why more companies aren’t using “evidence-based management,” which they define as the conscientious, explicit and judicious use of current best evidence in support of decision making [3]. Instead, companies seem to repeatedly adopt, then abandon, one ill-supported business fad after another. There exists, they point out, “a huge body of peer-reviewed studies—literally thousands...that although routinely ignored, provide simple and powerful advice about how to run organizations. If found and used, this advice would have an immediate positive effect....”

The failure of most businesses to use sound management science, they argue, is largely due to misinformation. They offer managers these warnings:

“People are trying to mislead you.” Because it’s so hard to distinguish good advice from bad, managers are constantly enticed to believe in and implement flawed business practices. A big part of the problem is consultants, who are always rewarded for getting work, only sometimes rewarded for doing good work, and hardly ever rewarded for evaluating whether they have actually improved things.”

“You are trying to mislead you”. People want easy solutions, but applying practices based on sound theory generally takes more effort. It requires] “a willingness to put aside convenient half-truths...and replace these with an unrelenting commitment to gather the

Figure 53: Barriers to using best practice, analytic, project portfolio management.
necessary factors to make more informed and intelligent decisions.” Simplistic approaches are popular because they do not force you to think very hard or to think in new ways.

Unless you are an expert in the relevant theories, it is tough to distinguish sound methods from snake oil. Managers don’t have the time to research all of the claims that land on their desks. Partial truths are the most difficult to defend against. Thus, concepts like balance and strategic alignment catch on, even though there is no defensible argument or evidence for claiming that they result in better project choices or improved performance for the organization.

To quote Ronald Howard, “In decision-making, as in many other pursuits, you have a choice of doing something the easy way or the right way, and you will reap the consequences” [4]. Checking the claims of those who are trying to sell you something may take effort, but it can save you from making serious mistakes. Check references. Be suspicious. Ask to see evidence to support claims. Get an objective opinion from an independent expert in the field.

**Misplaced Pride in Intuition**

In an article entitled “A Brief History of Decision Making,” Leigh Buchanan and Andrew O’Connell characterize the current era in which leaders seem to take pride in making decisions based on intuition as a “romance of the gut”[5].” The popular view is that real leaders don’t need analysis, “Intuition is one of the X factors separating the men from the boys” [6]. Recent years have seen two best-selling books on this theme. Psychologist Gary Klein’s book, *Intuition at Work*, advises managers to “trust your gut” [7]. Similarly, columnist Malcolm Gladwell’s best-selling book *Blink* argues that instantaneous decisions are often better than those based on lengthy rational analysis [8].

Behavioral psychologists Robin Hogarth and Paul Schoemaker provide a critical review of *Blink* [9]. They observe that Gladwell’s faith in intuition ignores the vast literature on biases (see Part 1 of this paper). They provide counterexamples to Gladwell’s examples and demonstrate that some of Gladwell’s own case studies seem to imply the opposite of his conclusions. Gladwell himself acknowledges that intuition is not always the best approach, and his book provides an example of how an analytic model is proving more effective than un-aided judgment in an urban hospital.

Author Barry Anderson observes that it “takes courage to be rational” [10].” Analysis can show that what we believe is not consistent with evidence and logic. Also, “analysis is a great leveler of hierarchy.” If the decision is going to be made by the facts, then everyone’s facts, assuming they are relevant and accurate, are equal. Unlike intuition, analysis can be learned. Analysis changes power dynamics, replacing formal authority, reputation, and intuition with information, data, and logic. This means that senior leaders, often venerated for their wisdom and decisiveness, may lose some stature if their intuitions are replaced by analysis.

Basing decision on intuition may be easy and attractive, but leaders need to decide what course is really in their best interests. Do they want to use intuition and avoid analysis that can prove them wrong, or do they want to use all effective means to ensure that their organizations actually perform well?

**Fear of Complexity**

For some managers, trying to select optimal project portfolios may seem too complicated to tackle.
Psychologists identify fear of complexity as one of the key pitfalls that prevent people from overcoming important problems. They point out that the perception of complexity is reduced, however, when people use information processing structures (what some psychologists call “description languages”) that provide a good fit to the complexities they encounter.

Systems modeling, the foundation for the methods described in this paper, is a language for describing and understanding complex problems. Models break a complex problem down into its individual pieces. The critical components are identified, sorted out, and analyzed separately. Computers perform the required synthesis at the end. As long as the concepts are understood, the fact that the math may be difficult is not really an issue; computers can handle the math.

Admittedly, systems modeling and the related methods that are described in this paper including multi-attribute utility analysis, probabilistic analysis, and risk tolerance, can themselves seem complex. Remember, though, that the most sophisticated tools need not be applied in all situations. If projects do not involve significant risks there is no need for probabilities and concepts like risk tolerance. More critical and difficult decisions require more sophisticated methods.

I urge organizations to follow the often quoted advice of Albert Einstein, "Seek the simplest possible solution, but no simpler." In particular, use methods that get the basic concepts right (e.g., the end goal is to create value, not balance). With learning and familiarity that come from experience, the appropriate methods will no longer seem complex.

**Discomfort with Uncertainty**

People would much prefer analysis to tell them what will happen, not what might happen. Thus, there is the perception that analysis is less useful in situations that are highly uncertain. Although there are well-established theories and techniques for optimizing decisions involving uncertainty (e.g., decision analysis), these are not topics about which most members of the public, or even most managers, are very familiar. Many managers assume that the great uncertainty over the costs and benefits of projects means that there is little value to applying sophisticated techniques to prioritize them.

My experience is that it doesn’t take much education for skeptics to agree that sophisticated methods based on probability can significantly improve decisions involving uncertainty. For example, roughly 40 years ago, probabilistic analysis was used to "beat" the game of blackjack. The sticking point seems to be whether the same methods have merit when probabilities must be based on models and judgment rather than purely on "objective data."

The following checklist of questions helps me decide whether I need to quantify judgmental uncertainty:

1. Is the uncertainty significant? If so, assessing a range of values for the uncertain quantity will make more sense, and be easier, than specifying a single-number best guess.
2. Does the uncertainty make a difference? Try varying the uncertain quantity across the range of possibilities. The uncertainty only matters if you would want to make decisions differently depending on the actual value.
3. Do experts believe some possibilities are more likely than others? If so, a probability distribution can be chosen to quantify those beliefs. I've never encountered a situation...
where the experts didn't have relevant beliefs, but if I did, there would be good reason to quantify the uncertainty using a uniform probability distribution, which assumes that all possibilities are equally likely.

Once uncertainties have been expressed as probability distributions, a probabilistic analysis is usually not much harder than the corresponding analysis without probabilities. It only becomes more difficult if the experts know a great deal, in which case such knowledge may need to be represented in more complex models that necessitate more sophisticated forms of analysis.

The existence of uncertainty does not undermine the usefulness of probabilistic methods. On the contrary, it enhances their usefulness. When significant uncertainties are present, only a systematic and rigorous approach can produce an accurate understanding of risk and support a sound logic for making risky decisions.

**Under-Appreciation of the Power of Judgment**

"But...," people say, "Probability obtained in this way are subjective!" Actually, everything associated with decision-making is subjective, but in the interest of space I won't get into those arguments!

People sometimes confuse subjectivity with bias. As demonstrated in Part 1 of this paper, estimates based on judgment are often biased. However, formal methods are available for mitigating most biases. In the area of probability assessment in particular, considerable effort has been devoted to developing techniques for eliciting probability judgments that accurately reflect the beliefs of those who provide them.

Organizations that eschew analysis because of its dependence on subjective judgment are, in my opinion, underutilizing what may be their most important resource. Consider the concept known as the “knowledge-based theory of the firm” [10]. The theory argues that knowledge is the only strategically important business resource. Other resources, like raw materials and electric power, are available at essentially the same prices to all competitors. Knowledge is the only resource that really distinguishes a company and can provide a real advantage. According to the theory, fundamentally what firms do is "apply knowledge to the production of goods and services."

Since knowledge is held by individuals and not the organization, "the central role of the enterprise and its management is to integrate distributed knowledge and make it usable" [11]. Models and probabilities provide the best-known means for doing this. Models capture in a clear and useful fashion people’s understanding about what makes the business successful. Probabilities encode beliefs about key uncertainties represented within the models in a precise, transparent way that can be understood by others and that can be readily used by the models to develop optimal decision strategies.

Although judgmental probabilities are indeed subjective, it is important to appreciate that they are not arbitrary. If a manager is using probabilities properly and says there is a 25% chance that the project will go over budget, that manager is saying that the degree of confidence in achieving the budget is the same as randomly selecting a red ball from an urn containing one red ball and three white balls. Thus, subjective probability is related to an objective reality. Expressing uncertainty as a probability...
gives a much more precise and useful statement than saying "it's uncertain." Judgmental probabilities can be processed to derive logical inferences. Furthermore, judgmental probabilities can be calibrated to experience. If there is ample evidence that only one-fourth of projects come in on budget, then, presumably, others will have more confidence in the 25% probability judgment.

**Predictive Markets**

Are subjective probabilities any good? Undoubtedly, the main reason that subjective probabilities aren’t used more often is the mistaken belief that they have little merit. But, awareness of the power of judgment is now gaining a significant boost based on the remarkable and well-publicized success of predictive markets. Around for years, these markets attracted attention after correctly calling close presidential elections (and, also, when they were rejected by the government as a method for predicting terrorist attacks).

In case you haven’t heard, predictive markets are betting markets wherein participants buy and sell shares of financial assets whose final values are tied to the outcomes of specific uncertain events (e.g., the outcome of an election). In effect, the market generates a price for the uncertain event that reflects a consensus probability that the event will occur. One of the oldest and most famous is the University of Iowa’s Iowa Electronic Market, which, since 1988, has been predicting the results of American presidential elections with more accuracy than polling services. A similar market correctly predicted all of the 2005 big category Oscar winners [12].

Even “game markets,” where players bet bragging rights rather than money, appear to result in good forecasts. According to one study, web-based betting competitions accurately predict movie box office returns, the winners of formula one racing events, and future developments in science and technology [13]. Predictive markets work because they produce forecasts in a way that effectively combines the knowledge of many participants while avoiding many of the biases identified in Part 1 of this paper.

Seeing opportunity, companies are beginning to create their own predictive markets, focusing on specific uncertainties that they want quantified. Hewlett-Packard, for example, has used internal markets to forecast sales and Eli Lilly has used them to predict the success of drug research [14]. Google recently reported that it uses predictive markets internally for generating strategic insights. The company compared the prices for events with the frequency with which the events occurred (if the prices are correct, events priced at 10 cents should occur about 10 percent of the time). The results were remarkably close [15].

The criteria for establishing a successful predictive market are the same as conditions that decision analysts have established for assessing subjective probabilities:

1. The uncertain quantity must be precisely and unambiguously defined (see the discussion on the clairvoyant test in Part 3).

2. Participants must have some knowledge of the relevant subject matter. (It has been observed, for example, that a predictive market that allowed the general public to bet on the veracity of “String Theory” in particle physics would likely not be a very accurate predictor.)

3. A motivation must exist for people to express what they really believe will happen (not what they would like to happen or what they think others want to hear).
Perhaps awareness of the success of predictive markets will cause more organizations to consider using analytic methods that properly rely heavily on judgment to evaluate and prioritize projects.
Competing on Analytics

There are reasons to be optimistic. As sophisticated methods gain use, evidence of their value is becoming more prevalent. So far, much of the data on the relationship between the use of analytic methods and business success is coming from the oil & gas and pharmaceutical industries. Such organizations are early adopters because high project costs and risks make bad decisions particularly costly. For example, an article in the journal Oilfield Review reports a study of 20 oil exploration companies that "established a strong positive correlation between the degree of sophistication in the companies' use of decision and risk analysis and the success of their project decisions." The same article also described another oil company study that found that "Companies that integrated workflow and used decision and risk analysis saw their performance improve shortly after the introduction of this methodology" [16]. A study of pharma stock price performance over a seven year period, found that companies that use decision analysis outperformed the Dow Jones Pharma Index by nearly 200% [17].

Of the numerous ways that analytics can improve organizational performance, project portfolio management (PPM), in particular, is receiving good press. SmithKline Beecham reported that finding the efficient frontier for a portfolio of 25 R&D projects increased expected return by $2.6 billion [18]. Focusing on value is key—Eastman Chemical reportedly doubled the worth of its R&D project portfolio as a result of making value creation the main metric for evaluating projects [19]. CIO Magazine reports a survey of portfolio management in product development applications that found that companies that achieve project portfolio management excellence experienced 50% faster revenue growth [20]. A similar study released in 2006 by the AberdeenGroup reports that companies that are best in class at product portfolio management are four times more likely to achieve margin premiums of 75% or higher from new products [21]. A study focused on R&D portfolios found that companies performing in the top 20 percent had previously installed an explicit, established method of project portfolio management across the organization [22]. In 2008, a market research firm estimated that project portfolio management software delivers over 500% ROI [23]. A recent cross-industry poll of project and portfolio management professionals and stakeholders indicated that two-thirds were either evaluating, implementing or have already deployed a PPM system [24].

Also, something new is happening—a few highly successful companies are making no secret of the fact that they have adopted superior analysis as a competitive business strategy. Explaining better than expected 2009 3rd quarter earnings, Cisco's CFO said, “We have continued our emphasis on operational excellence, portfolio management, and customer focus, all of which we believe positions us for future success” [25]. John Wilder, CEO of the utility TXU, claims to have cut costs “by more than $1 billion” through a series of initiatives that included bringing “analytic rigor to our portfolio decisions” [26]. American Express reports that the company applies its “Investment Optimization” portfolio process to all discretionary investments, and that the analysis results in “tens of millions of dollars being reallocated annually” [27]. In a video detailing Chevron's use of decision analysis, Chevron Vice Chairman George Kirkland states, "Decision analysis is a part of how Chevron does business for a simple, but powerful, reason: it works” [28].
In an HBR article entitled, “Competing on Analytics,” Thomas Davenport identifies eBay, Google, Amazon, and Dell, among others, as a new breed of companies that “are oriented to a much higher level of analytics: predictive modeling, optimization techniques – than we’ve been used to in the business world” [29]. They hire employees for their analytic expertise, provide them with the best available information, and arm them with the best quantitative tools. “As a result, they make the best decisions: big and small, every day, over and over and over.”

**Beat the 60% solution**

The introduction to this paper described the concept of the “60% solution,” the belief held by many that organizations only obtain about 60% of the value that could be derived from their businesses. As I have explained, I believe that choosing the wrong portfolio of projects is a major reason for lost business value.

The 60% solution can be beaten by doing a better job of choosing and managing project portfolios. It may not be easy, but it can definitely be done. The fact that optimizing project decisions is hard to do, but doable, is why organizations that address the problems identified in this paper can create for themselves a significant competitive business advantage.
References for Part 6

1. Numerous organizational maturity models have been developed. Models similar to that described here include the Organizational Project Management Maturity Model (OPM3®) developed by the Project Management Institute, the Portfolio, Programme and Project Management Maturity Model (P3M3®) developed by the UK Government, and the Capability Maturity Model Integration (CMMI®) developed by a group from industry and government at Carnegie Mellon University.


Choosing the Wrong Portfolio of Projects

Part 6: Achieving Best-Practice


25. Cisco, “Cisco CFO Frank Calderoni Offers Commentary on the Quarter” (video), www.youtube.com/watch?v=gCNwGG2YKHM.


