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Companies can use a Value Based Scorecard, developed using proven, research-based criteria, to select and prioritize NPD projects effectively.

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OVERVIEW: Effective portfolio management is vital to maximizing the value of the business' new product development (NPD) portfolio; it is also one of the weakest facets of NPD. Ongoing evaluation tends to be backward looking and process focused, and business cases are not updated with real time and more reliable data. A dynamic portfolio management approach is one solution, including the use of the Productivity Index (PI). Building in multiple iterations to get updated and robust data improves estimates of financial value and the PI. And since the value of a project depends on many factors, we present a multidimensional Value Based Scorecard that we developed using proven, research-based criteria, that companies can use to select and prioritize NPD projects effectively.

KEYWORDS: Portfolio management, New product development, Project selection, Value-based scorecards, Strategic buckets

Effective portfolio management is vital to maximizing the value of the business's new product development (NPD) portfolio. But NP project evaluation and making R&D investment decisions is one of the weakest facets of NPD. One issue is that, once a project is underway, much of the ongoing evaluation is backward looking and process focused: whether the project is on time and on budget, and reviewing checklists of deliverables. A second issue is that the project's business case is not updated and periodically reviewed as the project progresses.

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A dynamic portfolio management approach is one solution. The use of the Productivity Index (PI), which gauges the forward-value of an NPD project in real time, is useful: the PI captures the project's gain in value for every additional dollar spent. But financial metrics, such as the PI, often suffer from a lack of updated information and data integrity. Building in multiple iterations, complete with demos to customers that get updated constantly, creates robust data that greatly improve estimates of project financial value and the PI. Supplementing information with artificial intelligence (AI) and machine learning to undertake market analysis—as the LEGO Group, for example, does—also enhances data integrity.

Since the value of a project depends on many factors, using a multidimensional value-based scorecard can facilitate analysis. In this article, we present a multidimensional Value Based Scorecard that we developed using proven, research-based criteria, and which captures more than just the economic value of a project. Properly used with appropriate visuals, our Value Based Scorecard greatly enhances the decision-making process at gates and at real-time "upgates." Periodic portfolio reviews enable management to check that the portfolio has the right mix and balance of projects—by providing an average breakdown of resource allocation. Both the PI and the scorecard score are effective tools to prioritize projects at these portfolio reviews. Examples presented to illustrate key points are drawn from our collective research and work with clients; all information is presented with permission.

Winning at New Products

There are two ways to win at product innovation:

1. *"Do projects right."*—Much has been written about best practices in new product (NP) project execution regarding the need for voice of customer (VoC), robust front-end homework, an empowered cross-functional project team, and effective project management. Most firms now employ a detailed idea-to-launch process that emphasizes these and other best practices.
2. *"Do the right projects."*—As one executive exclaimed, "Even a blind man can get rich in a gold mine; you don't have to be the best miner, just be in the right mine." Doing the right projects is about project selection, picking winners, and making the right R&D investment decisions. That's what portfolio management is about.

Picking the best development projects is consistently shown to be one of the weakest facets of innovation management. The success rates of new products "approved for launch" is about 60 percent (Barczak, Griffin, and Kahn 2009). And the odds of success are much lower if one starts the clock earlier, say at the Go-to-Development decision point (closer to a 25 percent success rate). One could do almost as well by betting on black at a roulette table. Innovation Research Interchange (IRI) member firms rated their ability to select the right NPD projects and allocate resources to projects a weak 4 out of 10 (Cooper and Kleinschmidt 2021). Further, businesses rated poorly across a number of project selection practices, from no project prioritization method or portfolio management system in place to a lack of high value projects in their portfolios (American Productivity and Quality Center 2003; Cooper and Edgett 2012).

Lacking a project selection system, many management teams rely on gut feel and intuition. Relying on intuition is effective if the decision maker has developed their intuition through confronting many examples of the problem, as is the case for professionals like doctors (Mitchell et al. 2022). However, Mitchell et al. (2022, p. 3) explain that Kahneman has shown that "in unfamiliar circumstances, as is the case with many innovation projects, a decision-maker's intuition can be misled surprisingly easily. . . . Intuition must be supplemented with as much of a logical structure as possible."

Contrary to the tenet that project value metrics should look forward, in reality most ongoing project evaluation tends to be backward looking.

Poor project investment decisions have many negative impacts on NPD performance. Weak project selection decisions lead to higher NP failure rates, too many low-value development projects in the portfolio, and simply too many projects in the pipeline (Cooper 2021b; Dalton 2016; Edgett 2013; Thomke and Reinertsen 2012). As a result, vital key performance indicators (KPIs), such as the New Product Vitality Index (NPVI) or time-to-market, suffer. The NPVI, the most popular overall NPD performance metric, is defined as sales from new products launched in the last X years as a percent of the business's current annual sales. X is usually three years for consumer goods and five years for B2B products.

The Role of Dynamic New Product Portfolio Management

Portfolio management is about making difficult investment decisions on new product projects. Meifort (2016, p. 252) states that "new-product portfolio management is a dynamic decision process, whereby a business's list of active new-product (R&D) projects is constantly updated and revised. In this process, new projects are evaluated, selected, and prioritized; existing projects may be accelerated, killed, or deprioritized; and resources are allocated and reallocated to the active projects." Earlier research also reflects the dynamic nature of new product portfolio management (Cooper, Edgett, and Kleinschmidt 1999; Product Development and Management Association 2013).

For project selection to be effective, the time dimension must play a key role, in two ways:

1. Things change! Because the list of active projects is dynamic over time (updated and adjusted constantly), re-evaluating a project's value or business case in real time based on the latest information is vital. A dynamic portfolio points to the need to be constantly seeking updated and more reliable data as a project moves forward.
2. The appropriate metrics to use to gauge project value are those that are forward facing, not backward looking. The analogy is that of deciding whether or not to sell your shares of a specific company in the stock market; it matters not what you paid for the shares, or what happened last month, but rather, what will the share price or value be going forward? Sunk costs (and past events) are not relevant to the decision to move forward, except when previous events and outcomes are indicative of the future—for example, a project team that is historically late is likely to continue being late going forward.

Forward Facing Rather than Backward Looking

Contrary to the tenet that project value metrics should look forward, in reality most ongoing project evaluation tends to be backward looking. Most businesses—between 71 and 85 percent—use adherence to schedule, budget, and scope, along with quality of work done, to gauge project success (Project Management Institute 2021); businesses also use checklists of tasks or deliverables completed, and NASA's technological readiness levels (TRLs) (Cooper 2021b). These backward-looking metrics focus on what has happened in

the previous phase of the project! Many companies rely on the red-green traffic light as the main portfolio steering tool, at the expense of maximizing value. This familiar traffic light signal used in project management—red, yellow, and green lights—indicates behind or on schedule; if the project is "on schedule and on budget," then all is fine and the default decision is "continue."

While such progress assessments are useful, merely staying on schedule, within budget, or having certain tasks completed are poor reasons to continue spending. A project may be on schedule and within budget, but because the updated business case has changed, it may have lost its value and thus should be killed. The red-green light signal is backward looking and should not be the main go/no go criterion at a project review or gate meeting. Rather, the key question is: Does the project's value going forward justify the resources that must be invested to complete the project? Note these update reviews are not heavy gate meetings, but rather regular and quick looks at the updated business case and the project's prospects. Switzerland-based Sulzer Mixpac, which makes mixing and application systems for the dental and healthcare industry, calls these periodic management reviews "upgates" (Cooper and Fürst 2020).

Example: In an interview in 2022, Bo Bay Jørgensen, VP of engineering at Danfoss, a global manufacturer of controls and fluid handling equipment, reflected on the value of forward-facing analysis. "We now have more emphasis on the future than the past. Governance and Go/Kill decisions at gates must be based on the project's value being added going forward, and not on merely checking that tasks and deliverables have been completed—a "check-the-box" exercise," he said. "The governance has transitioned from an emphasis on process adherence and checklists to review future economic potential. This calls for an updated business case along the way with the latest view of the project's prospects."

Financial Metrics Often Don't Work

Most firms use some type of financial metric to gauge the attractiveness of a potential NP project, but challenges exist. NP portfolio managers look to rigorous and forward-looking economic evaluation methods, such as net present value (NPV), with sunk costs removed, to sharpen these go/no go decisions. The theory is right, but the data are often wrong (Aberdeen Group 2006; Edgett 2013). Some courageous firms have tracked their NPV estimates made at various gate decision points versus what actually happened to the product once launched. Usually this tracking data are confidential, but some firms have released their data. For example, P&G, a firm proficient in NPD, revealed that its forecasted NPV was less than half of the actual NPV on average (Mills 2007).

How useful is NPV as a go/no go criterion when it can be wrong by a factor of two? While technically the correct method for measuring economic value of a project going forward, NPV is an unreliable metric (Cooper and Sommer 2020). Not only do unreliable data foster poor go/no go decisions, they often lead to a lack of needed tough decisions and in a failure to kill underperforming projects, which then results in pipeline overload.

Validation Iterations to Update Data

One major benefit of the shift to Agile development is the constant updating of information, along with possible pivots in the project once underway. Nothing is stable for very long! As information gets updated, the new information is usually based on better sources and thus is more reliable. For example, in the first business case prior to development starting, initial estimates of sales volumes may be based on Salesforce "guestimates." But as the project moves forward, and with constant customer validations built in along the way, sales estimates become more and more based on customers' reactions—liking, interest, and purchase intent—and hence become more valid. The business case can be updated accordingly.

Smart firms thus build multiple iterations into the stages of their NP process in order to generate data to both validate the product and also to evaluate a project through the entire development process. The traditional gating process is linear, with the project moving from stage to stage according to a defined plan; there are no iterations. Testing with end users occurs once the development stage is finished, and as part of the validation phase (field trials, beta tests, consumer tests, test marketing). Often the project hits this validation stage only to run into trouble.

In an iterative model, multiple iterations are built in much earlier—a series of build-test-feedback-and-revise loops—whereby a "version of the product" is built, and then tested with the customer and also technically in the lab (Figure 1). Each iteration validates the product and moves the project closer to the final product design (Cooper 2022). The process moves from concept to rapid prototype to crude working model and pretotype, and finally to a true prototype. This iterative approach promotes experimentation, encouraging project teams to fail often, fail early, and fail cheaply, a principle that Steve Jobs applied at Apple (Isaacson 2011). The median interval between demos to customers is 17–24 weeks for physical products, according to one major European study (Sandmeier et al. 2010).

Continual customer feedback enables *more reliable estimates* of market acceptance, expected sales, customer value, and possible pricing (Cooper and Sommer 2020). Developing these successive product versions also builds insights into the technical solution, feasibility, and manufacturability, thereby improving estimates of development and manufacturing costs. This iterative hypothesis testing enables the project team to learn what is valuable to the customer or consumer and adjust the project's course accordingly, thereby increasing the value of the product and project to both the customer and to the development company. A key pre-launch test is the minimum viable product (MVP), a new product version that has enough features to satisfy early adopters; it provides solid information about customer reaction, customer value, and sales forecasts, as well as realistic cost information (Reis 2011).

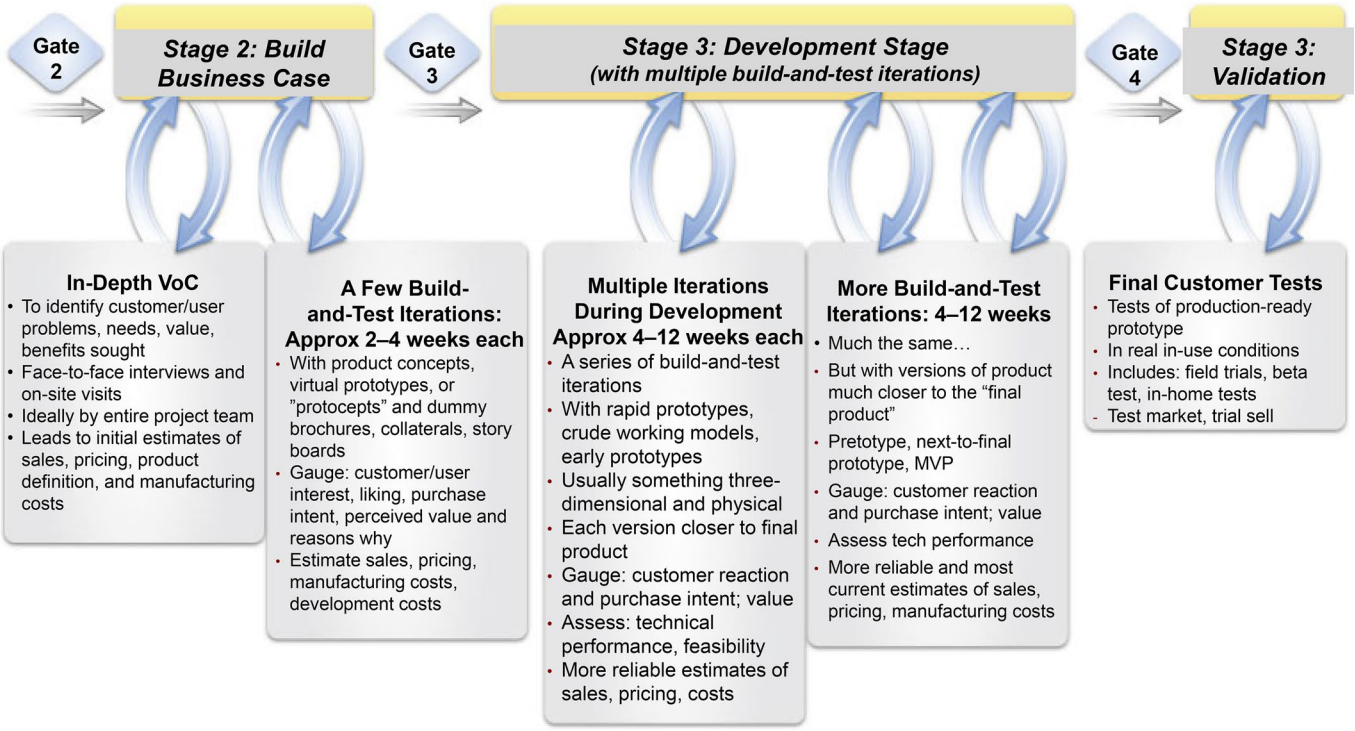


FIGURE 1. Multiple build-and-test iterations built into the stages of the NPD gating process, starting early in the process

Example: Armstrong, a US manufacturer of ceiling and wall components, developed its innovative architectural ceiling, ACOUSTIBuilt, a seamless acoustical ceiling system, using a series of build-and-test iterations throughout development (Wilkinson 2020). Although the general requirements for the product were known at the outset, the technical solution and detailed product definition were not, so the project called for an experimental, iterative approach. Armstrong used six iterations, each lasting several months, and each delivering a working prototype that was successively closer to the final product. At the end of each iteration, Armstrong tested the working prototype with users, obtained feedback, noted needed improvements, and then the next iteration begun. By building in the user all the way through, and seeking rapid feedback on working prototypes, the team was able to effectively zero in on the right product, as well as get better estimates of customer acceptance, likely sales revenue and manufacturing costs.

Agile development, successfully employed in the software world, is now being used by some leading physical product firms (Cooper and Sommer 2018). The Agile Scrum method, the most popular, incorporates many iterations throughout the entire process by way of a series of short two- to four–week build-and-test sprints followed by demos; thus Agile has data validation built in via sprint-iterations. The scrum version of Agile, however, says little about doing the right project—it focuses on how to do projects right. Effective project selection and gates are still very much needed; thus many manufacturers have retained their stage-and-gate process, and simply built Agile project management with its iterations into the stages, hence the Agile–Stage-Gate hybrid model.

In the front-end stages of the NPD process (idea generation and business analysis), the use of big data can have a dramatic impact, increasing product success rates by a factor of three.

Big Data, AI, and Machine Learning

Big data is transforming the NPD process and has a significant role in improving the accuracy of front-end data (Ban, El Karoui, and Lim 2016). By analyzing large amounts of data and related knowledge—such as customer behavior, market trends, and competitor strategies—organizations can make more informed decisions (Del Vecchio et al. 2022). Research has shown that companies that use big data–embedded NPD processes have significantly higher rates of new product success compared to those that do not (Wang, Zhang, and Song 2020). In the front-end stages of the NPD process (idea generation and business analysis), the use of big data can have

a dramatic impact, increasing product success rates by a factor of three. However, integrating big data into the NPD process is itself a process that few organizations have fully mastered.

Leading companies are using AI and machine learning algorithms to assist in gathering and analyzing data, such as for market analysis. These algorithms are becoming increasingly valuable in capturing new consumer and customer patterns for making product and marketing decisions. AI is also being used to forecast demand for new products by identifying the key drivers of sales, with promising results (Columbus 2020). Many software tools and AI firms provide market data and market analysis—examples include Monday, Funnel, and SAS Customer (Capterra 2022).

Example: The LEGO Group uses market insights tools based on machine learning to analyze emerging trends and predict product growth based on publicly available data from the Internet, such as likes or clicks on trending videos or memes. This information gets shared with product developers to increase their understanding of consumer and shopper trends.

Using This Reliable, Real-Time Data

Companies can use real-time data to evaluate projects via the productivity index or a multidimensional value-based scorecard.

Tracking the Productivity Index

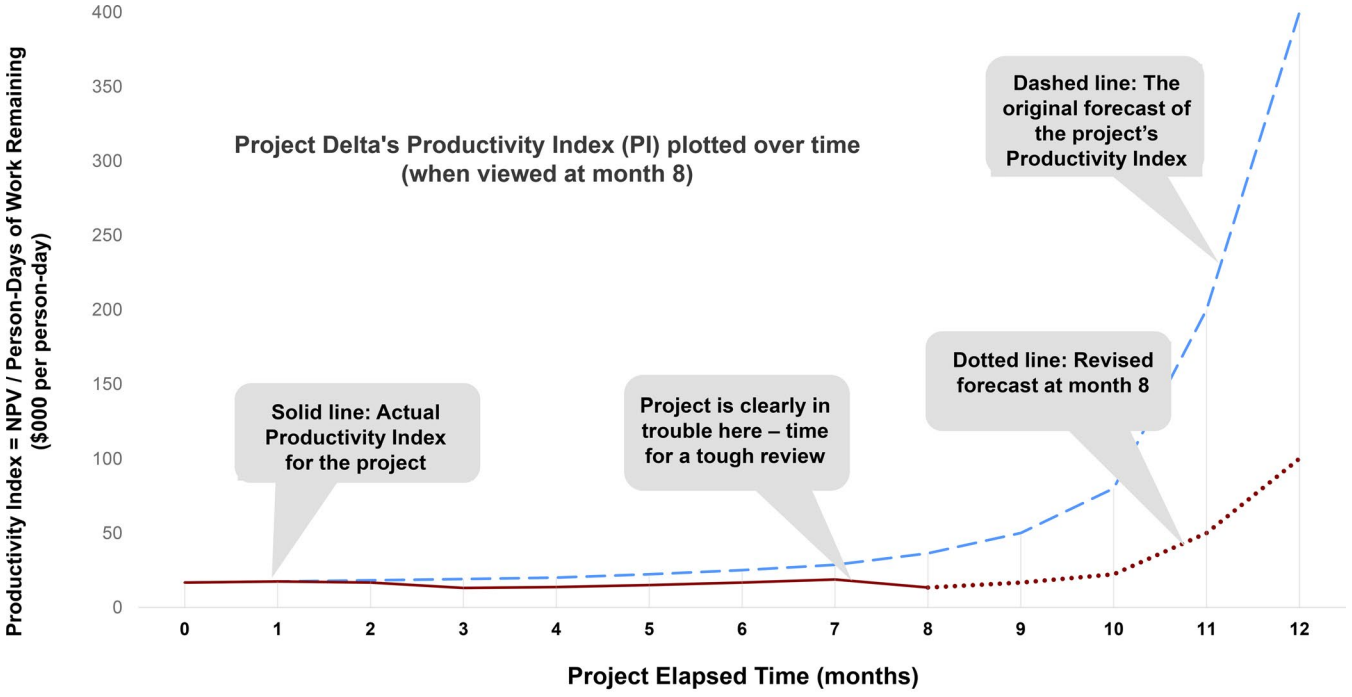
Build-and-test iterations, together with better front-end homework assisted by AI, yield more robust real-time data, the missing ingredient in many NP businesses case financial calculations. Now, armed with more reliable and updated data, financial tools can be employed more effectively. Besides the NPV, the PI is a powerful forward-looking metric to gauge the economic value of a project in a dynamic, real-time way (Matheson, Matheson, and Menke 1994). The PI is simply the value of the project divided by the constraining resource, usually person-days or dollars (Cooper and Sommer 2020; Cooper 2021a). Person-days is the number of full work days that people spend working on the project; it is not the same as calendar days, which are elapsed time. For example, a team of five people working full-time for a week on the one project equals 20 person-days.

The PI gauges the "bang for buck"—that is, what value is added for every additional unit of scarce resource—person-days or dollars—that is spent on the project:

$$\text{Productivity Index} = \frac{\text{Output}}{\text{Input}} = \frac{\text{Project NPV}}{\text{Dollars remaining to be spent}} \text{ or } \frac{\text{Project NPV}}{\text{Person days needed to complete the project}}$$

In practice, one simply takes the estimated NPV from the project's business case, updated as the project moves forward, and divides by the person-days or dollars that must be spent in order to complete the project. Note that sunk costs are not relevant to the determination of the PI, only the "go forward" costs and person-days are counted.

Example: Project Delta (fictional) is tracked over time for its one-year development, using its PI (Figure 2). The PI



Note: The chart shows the project in trouble—it's starting to lose value due to unexpected additional person-days spent at month 7 and only modest "customer liking" at demos.

FIGURE 2. Productivity Index (PI) plotted over time to gauge the project's economic health going forward

starts out at $16.7K per person-day at the point of project approval (at month 0), and ideally should follow the upper line, steadily upwards (the dashed line is the original forecast). Note that as one approaches the end of the development (month 12), there are fewer and fewer person-days of work remaining to be done, so the dashed line forecast starts to rise quickly as the PI's denominator approaches zero (Cooper 2021b).

At month 7, however, Project Delta gets into trouble: The business case is revised downwards due to less-than-enthusiastic customer feedback on early prototypes, and also the number of days to complete the project increases because some tasks are taking longer than forecasted. At month 7, the PI (solid line) starts to dip—the additional person-days spent yield lower incremental value—and thus signals that it's time for a tough rethink of this project. The revised PI forecast for the rest of the project (the dotted line) is also disappointing. An immediate go/no go gate meeting is scheduled.

The PI reveals the incremental benefit (or marginal value) of spending each additional dollar or person-day on the project; it is thus a superb tool for project tracking. Tracking the project with the PI signals a negative situation that might trigger an immediate project review, resulting in a kill decision, or a pivot for the project.

A second, less evident, benefit of using the PI is that it is an approximation of the project's risk level. Many financial people use the risk/reward ratio to indicate whether the project has an acceptable risk level: How much money do we stand to win in this gamble versus how much money could we lose? The hoped-for gain is the NPV; the possible loss is the all-in dollars to be spent going forward. Thus the risk/reward ratio at any point in the project can be approximated by:

$$\text{Reward / Risk} = \frac{\text{Project NPV}}{\text{Dollars remaining to be spent}}$$

which is simply the PI!

Evaluating Projects Using a Multidimensional Scorecard

"Value of the project" depends on many factors: economic value for the shareholder (for example, measured by the project's NPV or PI), helping the business achieve its mission (for example, environmental impact or meeting environmental, social, and governance [ESG] goals), and strategic importance (for example, targeting a new market deemed vital for long-term success). What becomes obvious is that a single variable model, such as NPV or return on investment, while useful, cannot gauge the multidimensional facet of "value of the project." The one multiple dimensional model that can (and is proven both useful and predictive) is the value-based scorecard model.

Numerous factors have been shown to correlate strongly with new product success and value in countless success/failure studies (Product Development and Management Association 2023). As a result, research-based scorecard models have been developed that predict new product outcomes very well, as high as 83 percent accurately pre-development (Bronnenberg and van Engelen 1988). Many of the best scorecard models were developed privately within corporations, but in recent years, more are available in the public domain.

Our Value Based Scorecard is for major development projects and for the major investment gates.

A Validated Value Based Scorecard

Five key factors were found to be the best predictors of project value and success (Table 1). One can see each factor and the strong empirical evidence in its support.

We constructed our Value Based Scorecard using these five factors (Figure 3). This scorecard is for major development projects and for the major investment gates—namely, Gates 3, 4, and 5 in Figure 1. For ongoing real-time project reviews (upgates following each iteration and demo), we suggest an abbreviated scorecard, which is easier and faster to use. And for smaller projects, even simpler criteria are appropriate (see "Criteria for Evaluating Smaller or Lower Risk Projects" on page 23).

A few factors, such as *Strategy and Mission* and *Leverages Core Competencies,* usually stay relatively stable over time; others, such as *Customer Energizer*, *Reward/Risk* (financial), and *Technical Feasibility* can change over time with the benefit of updated information that results from multiple build-and-test iterations.

Aligning the scales is one challenge in operationalizing a scorecard. This alignment means ensuring that a score of 5 out of 5 on one scale, such as *Customer Satisfaction*, is equivalent to a 5 on another scale, such as the *Project's NPV*. Mitchell et al. (2022) provide one method for aligning the scales, which involves choosing a midpoint or "pivot

Criteria for Evaluating Smaller or Lower-Risk Projects

Such projects merit their own criteria—either a simpler scoring model or an easier-to-compute profitability metric than NPV, such as the payback period. If strategic buckets are used, whereby projects are sorted by types—major innovations, product improvements, cost reductions, etc.—then one can use different rating criteria for different types of projects (the 5-factor scorecard in Figure 3 for major projects; the payback period plus a simpler scorecard for smaller, lower risk projects; etc.).

TABLE 1. Value Based Scorecard factors proven to correlate with NP project success and thus excellent for project selection

#	Factor	Factor Description	Rationale for Factor
1	**Mission and Strategy**	The project aligns with and is important to the business's mission and its innovation strategy (one must have a clearly defined business and innovation strategy, and a well-defined and visible mission statement).	Strategy and mission guide business decisions such as NPD project selection; both chart the way forward for NPD. Having a new product strategy is strongly linked to positive NPD performance (American Productivity and Quality Center 2003; Cooper 2019; Dwivedi, Karim, and Staresinić 2021; Kock and Gemünden 2016; Product Development and Management Association 2023).
2	**Customer Energizer**	The new product is an energizer: it will delight the customer; has a "wow" factor; is a unique and superior product in the eyes of the customer/user; offers customer unique benefits; and has a compelling value proposition.	Customer satisfaction and unique, superior products in terms of meeting customer needs are key drivers of NP success; some studies show this as the #1 factor (Evanschitzky et al. 2012; McNally, Cavusgil, and Calantone 2010; Product Development and Management Association 2023). Numerous studies reveal very strong correlations between this factor and NP project outcomes (success, profitability).
3	**Synergy: Leverages Core Competencies, Familiar Area**	Synergy: The project leverages the business's core competencies and strengths; firm's strengths are a good fit with the project's resource needs—marketing, operations, technical; takes the firm into familiar areas—well-known markets, operations, technologies.	Synergy and leveraging core competencies is key to success (Cankurtaran, Langerak, and Griffin 2013; Cooper 2019; Evanschitzky et al. 2012; Product Development and Management Association 2023). The role of leverage is derived from the adage of "attacking from a position of strength." Familiarity is also a known success driver: step-out projects taking the firm into new areas—unfamiliar markets and technologies—have a much higher likelihood of failing (Product Development and Management Association 2023).
4	**Technical Feasibility**	Four sub-questions determine the likelihood of technical feasibility: size of technical gap (new science and invention required?); technical complexity (many versus few tech hurdles; no solution envisioned); and technical uncertainty.	The likelihood of technical feasibility is an obvious and frequently reported factor in NP project success. The four sub-questions that most often predict technical success probability are less obvious, and are from Cooper (2017, pp. 306–308).
5	**Reward versus Risk**	Net present value (NPV) gauges the project's value to the shareholder. The Productivity Index (PI) measures efficiency of spending (marginal value of additional resources spent), and is also a proxy for the Risk/Reward ratio.	Such a financial factor is mandatory. While significant errors exist in NPV, NP success is still correlated with achieved NPV, and thus merits inclusion. The Productivity Index is included for reasons cited in the article.

Value Based Scorecard (VBS)

Five Proven Criteria for Project Selection	1	3	5	Score (1–5)
1. Mission and Strategy • Fits our business's strategy and mission; important to our mission and strategy	• Not in alignment with, or important to our business strategy and mission; not important to do: KILL	• Aligns with our strategy and mission; moderately important to do strategically and for our mission	• Product aligns very well with our business strategy and mission; very important to our strategy and mission	
2. Customer Energizer • Will delight the customer; has a "wow" factor • Has a compelling value proposition; a unique and superior product in the eyes of the customer/user • Offers customer unique benefits • Based on customer feedback at demos	• Essentially the same as the competition; no "wow" factor • No compelling value proposition • No unique benefits • Negative/neutral customer feedback from demos	• Somewhat different than competition • Modest value proposition, but no real "wow" factor • Moderately compelling value proposition • Moderately positive feedback	• Clearly differentiated from competitive products; has a clear "wow" factor • A strong compelling value proposition • Offers unique benefits to the customer • Based on strong feedback from demos	
3. Synergy: Leverages Core Competencies and a Familiar Area • Development technology, marketing, operations	• No synergy; does not leverage our competencies; do not have the needed technical, marketing, operational skills, knowledge, and resources; unfamiliar areas to us	• Some synergy; leverages our core competencies somewhat; we have most of the technical, marketing, operations skills and resources; somewhat familiar to us	• Synergy; leverages our competencies well; we have the technical, marketing, operations skills and resources; very familiar areas to us—we know them well	
4. Technical Feasibility • Size of technical gap • Technical complexity (many tech hurdles) • Demonstrated technical feasibility (proof of concept)	• Low feasibility • Big technical gap (must invent new science) • Many tech hurdles; no experience, high uncertainty • No proof of concept yet	• Quite feasible • Moderate technical gap • Some tech hurdles, but doable • Some experience here, moderate uncertainty • Close to proof of concept	• High feasibility • Small technical gap (a repackaging of existing technology) • No real tech hurdles, solutions evident; lots of experience here • Proof of concept demoed	
5. Reward/Risk • Profitability; net present value (NPV) • Payback Period • Risk/Reward ration (Productivity Index)	• NPV negative or zero at risk-adjusted discount rate • Payback Period > 5 years • Productivity Index < hurdle: KILL	• NPV is positive but not huge • Payback Period about 3 years • Productivity Index = hurdle	• NPV very positive at risk-adjusted discount rate • Payback Period < 2 years • Productivity Index > hurdle	

FIGURE 3. Value Based Scorecard gauges project value going forward to evaluate NP projects

statement" on each scale that is equivalent. A second challenge is that some criteria are more important than others and thus should be weighted more heavily. Arriving at an agreed set of weights can be problematic, however, unless a study of actual projects has been undertaken to arrive at statistically derived weights. Thus, normally one assumes that all criteria are of approximately equal importance but does put a threshold value (a lower limit) on some scales that signals a kill decision—in effect, placing a large weight on some scales when their scale values are low).

Using the Value Based Scorecard

The Diamond Diagram provides an ideal format of an effective project go/no go meeting (Figure 4). The project team presents its project, and a vigorous question-and-answer session ensues, where the evaluators challenge the project team. Then a quick check is made to ensure that all the required work has been done, and that key risks are under control—a Readiness Check (Diamond #1). See sample check questions (Figure 5). Next, is assessment of the project's value (Diamond #2): Each of the evaluators independently scores the project on the Value Based Scorecard. The results are immediately displayed on spreadsheet on a large screen, including an overall or project value score (Figure 6).

The gate facilitator highlights areas of disagreement among the evaluators: Significant disagreements exist on the criterion *Customer Energizer* (Figure 6). The high and low scores are not discarded—rather these extremes are identified, and those evaluators are asked to defend their very high or very low score. Each evaluator's overall score (out of 100) is shown in the final column. Only one evaluator, designated RS (the R&D director), has rated the project poorly, largely because of her low scores on *Customer Energizer* and *Technical Feasibility*. A facilitated discussion ensues. Finally, agreement is reached, and a go/no go decision is made. For a major project, this facilitated gate meeting should last no more than 60 minutes (Gates 3, 4, or 5 in Figure 1). For a quick review in real time—an upgate after a demo—the meeting should last about 30 minutes, using an abbreviated scorecard and readiness checklist.

Some evaluators prefer a visual X-Y plot of the results. The five factors are split into two groups to portray the project's *Opportunity* versus *Feasibility* (Figure 7). Projects in the upper right quadrant are the desired ones or "potential stars." Additionally, some firms allow the project team to score themselves. To avoid bias, these team scores are not displayed until the evaluators have scored the project; all scores are then displayed together.

The Value Based Scorecard's Behavioral Value

Scorecard users indicate that, although the overall or project value score is useful to prioritize projects, the real value in the Value Based Scorecard is the behavioral aspect—the fact that a group of senior people meet, discuss the project, walk through a set of key questions, debate the questions, reach closure, and then make a decision.

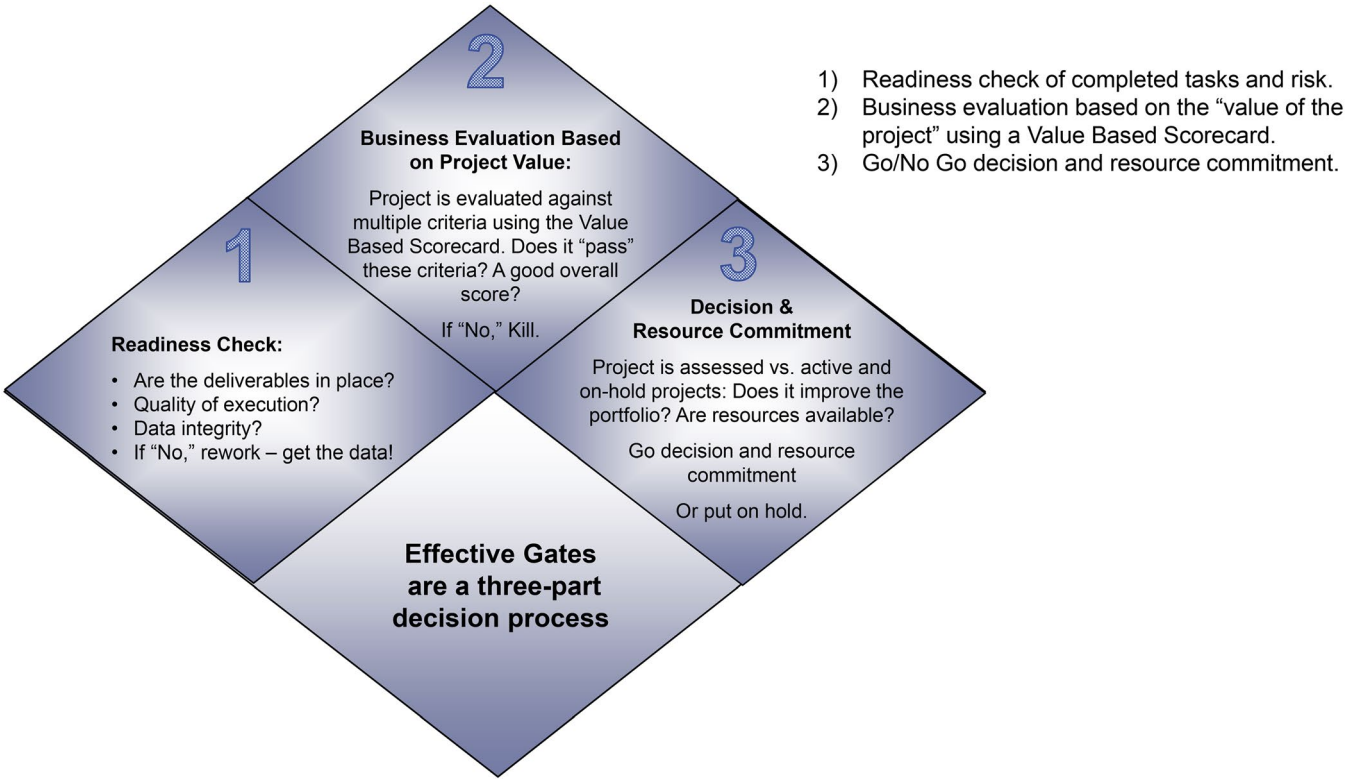


FIGURE 4. Structure of a gate with its three components: 1) Readiness check; 2) Business evaluation based on project value; 2) Decision and resource commitment

Work is done and with data integrity (reliable data)	Yes	No
1. Voice of customer study, concept test, competitive analysis, market analysis—all done proficiently		
2. Technical feasibility and operations assessment (source of supply)—done proficiently		
3. Product definition in place —fact based (what % is complete)—done proficiently		
4. Business case in place and financial analysis—done proficiently		
5. High-level plans through to launch in place		
6. Preliminary launch plan and operations plan in place		

Readiness Level	Low	Med	High
1. To what extent has the expected value increment been realized from the last phase of the project (e.g., in an early prototype, validating hypotheses, reviewing the customer/user experience?			
2. Has the next-stage value increment been assessed? What is the expected learning or value of the next phase or iteration?			
3. To what extent are the target customers actively involved in the project?			
4. To which degree do you have functional and developmental support from various departments?			
5. How mature is the technology?			
6. To which extent have the requirements for new capabilities been mitigated?			
7. Is "quantity or sales volume" the current challenge? Rate the risk.			
8. Is technical the current challenge? Rate the risk.			
9. Is operations and/or source of supply the current challenge? Rate the risk.			
10. Other risks? List and rate the risk of each.			

FIGURE 5. Readiness check questions, which are addressed first at the project review or gate meeting

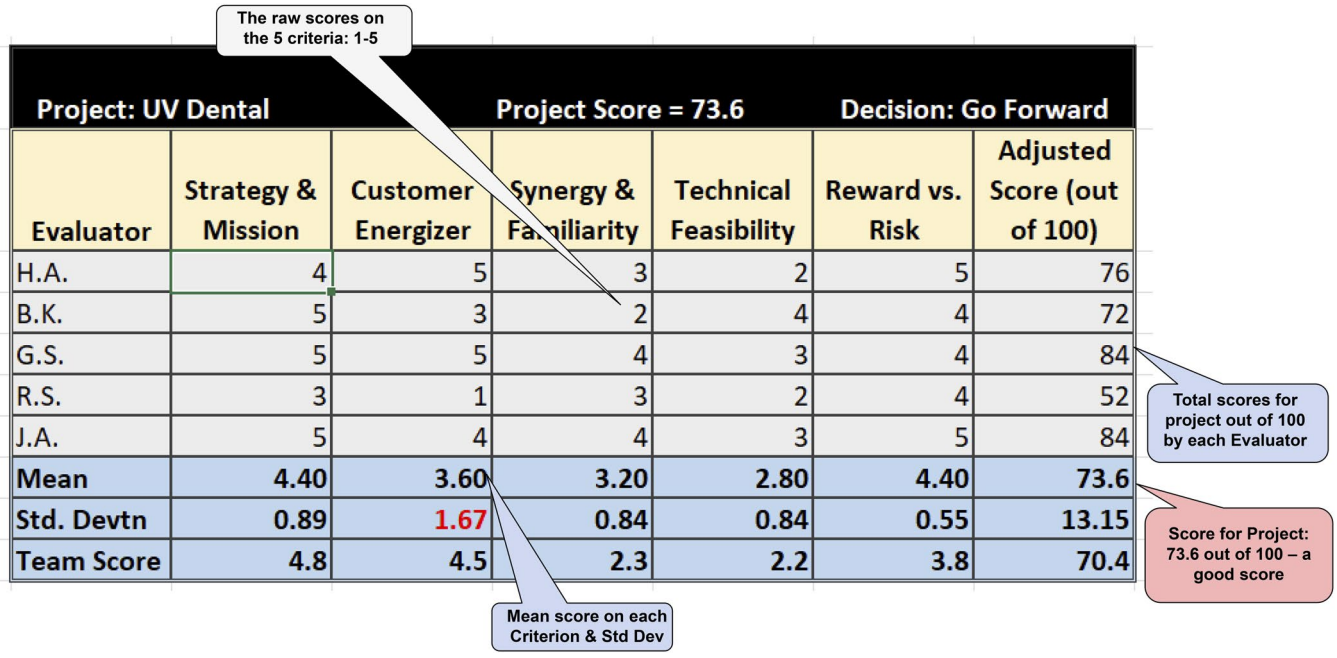


FIGURE 6. Value Based Scorecard scores displayed on a large screen at the decision or review meeting

Users also like the fact that scorecards render individual judgments of all gatekeepers visible—there is total transparency at the gate meeting. And they like that gatekeepers have an opportunity not only to challenge the project team but also to debate differences among themselves and hence achieve more informed decision-making. It is the management thought process, and not so much the project score, that is the real benefit.

Example: St-Hubert, a major Canadian food company, shared feedback on the Value Based Scorecard. "The scorecard method has proven very valuable for choosing the best projects in the past three companies I've worked for. It ensured

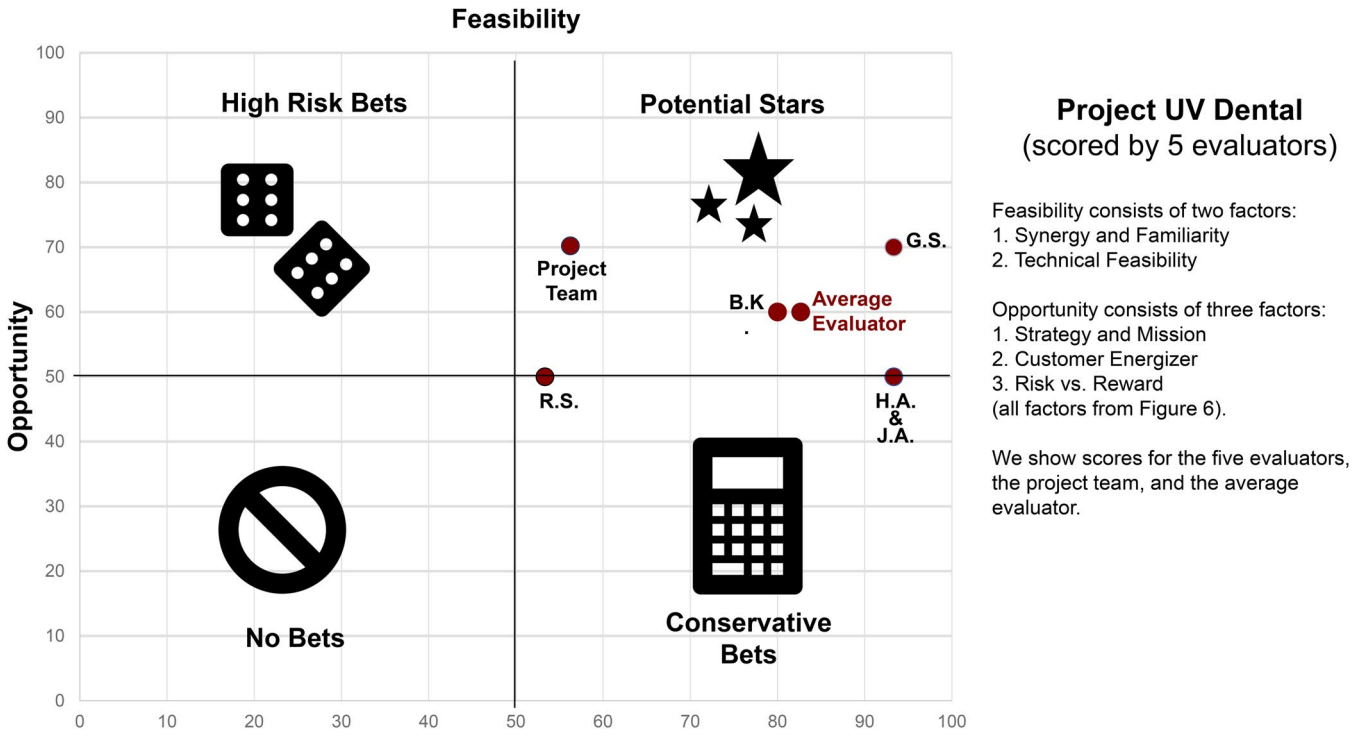


FIGURE 7. Plot of opportunity versus feasibility

that the right issues were considered—strategic impact, product differentiation, market attractiveness, financial viability," said Nathalie Gauthier, St-Hubert's senior director of marketing. "The scorecard not only led to better decisions, it also generated insightful discussions, creating a clear and common understanding [across departments] about the reasons why we should, or should not, invest in each new product project."

Portfolio Reviews

Periodic portfolio reviews also benefit from forward-facing metrics with updated data. A portfolio review looks at the "forest"—that is, the entire set of projects in the portfolio (often broken down by strategic buckets) (Cooper and Sommer 2020). By contrast, gate decision meetings focus on the "trees"—that is, one or a few projects (Cooper and Sommer 2020). Portfolio reviews are typically held about every quarter.

One key question in a portfolio review is to assess whether the business has the right allocation of resources across project types. For example, is the resource breakdown across buckets consistent with the business' strategy and mission, and is it consistent with industry practice? Or does the business have too high a proportion of resources devoted to small, incremental projects and not enough in the bolder innovation bucket? We present a breakdown from an IRI study, which serves as a guide (Figure 8) (Cooper and Kleinschmidt 2021).

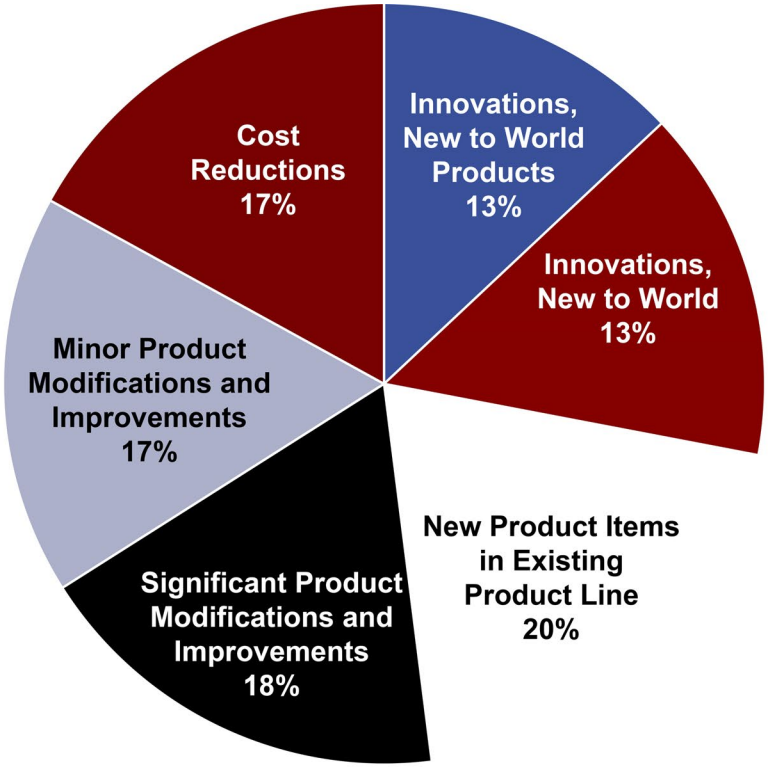
A second issue at a portfolio review is focus: Are there too many projects for the resources available? This involves a prioritization or forced ranking of NP projects, based on value-based criteria. This ranking works better if done within a strategic bucket, not across buckets.

Example: Clay Products (disguised name) begins a portfolio meeting with a list of six projects previously approved and underway in the "new products bucket." Some are under-resourced and moving slowly. The resource demand ($2.6 million per quarter) is almost double the resource availability (the budgeted amount for this new products bucket is $1.5 million per quarter). The development cost (cost of full-time equivalent people [FTEs] per project)—column 2 in Table 1—is a realistic portrayal of the resource demand or need per project (for the quarter).

The six projects are then force-ranked from best to worst using both the PI and the score from the Value Based Scorecard (a scorecard very similar to Figure 3), and relying on latest results (that is, the scorecard score and the PI from the project's most recent evaluation). We present the ranking and both the PI and Value Based Scorecard scores (Table 2).

After ranking the projects and adding up resources per project (column 6), the resource limit is reached after the fourth project. Thus, the last two of the six projects are put

It is the management thought process, and not so much the project score, that is the real benefit.



Note: Such a pie chart provides a guide. But each business' unique strategy and goals should determine its desired resource breakdown.

FIGURE 8. Average breakdown of NPD resources across project types or strategic buckets (Cooper and Kleinschmidt 2021)

on hold, and their resources are reallocated to higher value projects. As a result, the other four higher-ranked projects see their resources increased by a factor of almost two and can now move faster. Note that the original "best project"—Drilling Fluid with the largest NPV—is deprioritized to a "hold," simply because it consumes so much of the scarce resource, the FTEs (people cost and their time). It is a simple but tough procedure, and very effective.

An alternate strategy, the default strategy that Clay Products had been following, is to do all six projects—that

TABLE 2. Results of forced-ranking of projects in the "new products" bucket at a portfolio review

Project	NPV ($M)	Dev Costs ($ per quarter)	Productivity Index = NPV / Dev Costs (and column ranking)	VBS Score (and column ranking)	Forced Ranking 1–6 (based on PI and VBS score)	Sum of Dev Costs ($ per quarter) After Forced Ranking	Decision After Forced Ranking	Resources Allocated After Ranking ($)
Column #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Super-Opaque Sheet	5.7	$500,000	11.4 (1)	78.1 (2)	1	$500,000	**Go**	$500,000
Mineral Replacement	2.8	$300,000	9.3 (3)	82.5 (1)	2	$800,000	**Go**	$800,000
PE Filler-1	4.8	$500,000	9.6 (2)	75.0 (3)	3	$1,300,000	**Go**	$1,300,000
Cosmetic Grade	0.8	$200,000	4.0 (5)	77.2 (4)	4	$1,500,000	**Go**	$1,500,000
						Limit Reached		
Drilling Fluid	5.8	$1,000,000	5.8 (4)	69.1 (5)	5	$2,500,000	**Hold**	0
Adsorbant-100	0.15	$100,000	1.5 (6)	65.1 (6)	6	$2,600,000	**Hold**	0
Total		$2,600,000						$1,500,000

Note: Development budget for this new product bucket is $6 million ($1.5 million per quarter).
Dev costs = Development costs; NPV = Net present value; PI = Productivity Index; VBS = Value Based Scorecard
With six active NP projects underway, resources available ($1.5 million per quarter) are half the resources required if all six projects are undertaken with proper resource loading ($2.6 million, column 2). The forced ranking, based on the Productivity Index (column 3) and the Value Based Scorecard scores (column 4), help to rank the projects from best to worst (column 5). The outcome: the last two projects are put on hold and no resources are allocated. Now resource supply ($1.5 million) equals resource demand (column 8). The example, based on a real portfolio review, has been simplified for illustrative purposes.

is, reduce resources to approximately half the need for each project, and move each at half the speed. But money has a time value, and an NPV calculation shows that a focused strategy—cut two projects and resource the other four properly—is more financially attractive.

Maximize Your R&D Productivity

New product R&D projects are investments. And like a portfolio of stocks and bonds, there are good ways and bad ways to manage that portfolio to maximize productivity (payoffs versus resources invested). If your business lacks effective NP portfolio management—too many projects, difficulty killing weak projects, no portfolio or project selection system, and a low value portfolio for the resources spent—then consider some of the dynamic portfolio management solutions presented here. No system will guarantee that you consistently pick the right NPD project investments, any more than one can do that when making stock market investments. But if you can *improve the odds of winning*—do better than the current one-out-of-four odds—then the effort has a huge payback.

References

Aberdeen Group. 2006. The Product Portfolio Management Benchmark Report 2006: extension://elhekieabhbkpmcefcoobjddigjcaadp/https://www.plm.automation.siemens.com/zh_cn/Images/aberdeen_portfolio_mgmt_tcm78-5843.pdf

American Productivity and Quality Center. 2003. *Improving New Product Development Performance and Practice*. Houston, TX: APQC Publications.

Ban, G-Y., El Karoui, N., and Lim, A. E. B. 2016. Machine learning and portfolio optimization. *Management Science* 64(3): 1136–1154 doi: 10.1287/mnsc.2016.2644

Barczak, G., Griffin, A., Kahn, K. B. 2009. Trends and drivers of success in NPD Practices: Results of the 2003 PDMA Best Practices Study. *Journal of Product Innovation Management* 26(1): 3–23. doi: 10.1111/j.1540-5885.2009.00331.x

Bronnenberg, J. J. A. M., and van Engelen, M. L. 1988. A Dutch test with the NewProd-Model. *R&D Management* 18(4): 321–332. doi: 10.1111/j.1467-9310.1988.tb00607.x

Cankurtaran, P., Langerak, F., and Griffin, A. 2013. Consequences of new product development speed: A meta-analysis. *Journal of Product Innovation Management* 30(3): 465–486. doi: 10.1111/jpim.12011

Capterra. 2022. Top ten marketing analysis tools: Marketing analysis software. https://www.capterra.com/sem-compare/marketing-analytics-software/?utm_source=bing&utm_medium=cpc&utm_campaign=:1:CAP:2:COM:3:All:4:US:5:BAU:6:SOF:7:Desktop:8:BR:9:Marketing_Analytics:11:WCI

Columbus, L. 2020. 10 ways AI is improving new product development. *Forbes*, July 9. https://www.forbes.com/sites/louiscolumbus/2020/07/09/10-ways-ai-is-improving-new-product-development/?sh=27a90ce45d3c

Cooper, R. G., and Kleinschmidt, E. 2021. An update to the 2004 benchmarking best NPD practices study. Innovation Research Interchange. https://www.pathlms.com/iri-learningcenter/events/2345

Cooper, R. G. 2017. *Winning at New Products: Creating Value Through Innovation*. 5th ed. New York, NY: Basic Books, Perseus Books Group.

Cooper, R. G. 2019. The drivers of success in new-product development. *Industrial Marketing Management* 76:36–47. doi: 10.1016/j.indmarman.2018.07.005

Cooper, R. G. 2021a. Accelerating innovation: Lessons from the pandemic. *Journal of Product Innovation Management* 38(2): 1–11. doi: 10.1111/jpim.12565

Cooper, R. G. 2021b. Unlocking 'pipeline gridlock': Effective portfolio management is the key. *Innovation Management*, November 8. https://innovationmanagement.se/2021/11/08/unlocking-pipeline-gridlock-effective-portfolio-management-is-the-key/

Cooper, R. G. 2022. The 5th generation Stage-Gate idea-to-launch process. *IEEE Engineering Management Review* 50(4): 43–55. doi: 10.1109/EMR.2022.3222937

Cooper, R. G., and Edgett, S. J. 2012. Best practices in the idea-to-launch process and its governance: A study of new-product development practices at 211 businesses provides insights into best practices. *Research-Technology Management* 55(2): 43–54. doi: 10.5437/08956308X5502022

Cooper, R. G., and Fürst, P. 2020. Agile development for manufacturers: The emergent gating model. *Innovation Management*, November 10. https://innovation management.se/2020/11/10/agile-development-for-manufacturers-the-emergent-gating-model/

Cooper, R. G., Edgett, S. J., and Kleinschmidt, E. J. 1999. New product portfolio management: Practices and performance. *Journal of Product Innovation Management* 16(4): 333–350 10.1016/S0737-6782(99)00005-3

Cooper, R. G., and Sommer, A. F. 2018. Agile-Stage-Gate for manufacturers—Changing the way new products are developed. *Research-Technology Management* 61(2): 17–26. doi: 10.1080/08956308.2018.1421380

Cooper, R. G., and Sommer, A. F. 2020. New-product portfolio management with agile: Challenges and solutions for manufacturers using agile development. *Research-Technology Management* 63(1): 29–36. 10.1080/08956308.2020.1686291

Dalton. M. 2016. Manage pipeline bandwidth to avoid derailing new products. *Industry Week*, August 23. https://www.industryweek.com/process-improvement/managepipeline-bandwidth-avoid-derailing-new-products

Del Vecchio, P., Mele, G., Passiante, G., and Serra, D. 2022. Knowledge generation from big data for new product development: A structured literature review. *Knowledge Management Research & Practice* doi: 10.1080/14778238.2022.2094292

Dwivedi, R., Karim, F. J., and Starešinić, B. 2021. Critical success factors of new product development: Evidence from select cases. *Business Systems Research* 12(1): 34–44. doi: 10.2478/bsrj-2021-0003 10.2478/bsrj-2021-0003

Edgett, S. J. 2013. *Portfolio management for product innovation. The PDMA Handbook of New Product Development*, 3rd ed., edited by Kenneth B. Kahn, 154–166. Hoboken, NJ: John Wiley & Sons, Inc.

Evanschitzky, H., Eisend, M., Calantone, R. J., Jiang, Y. 2012. Success factors of product innovation: An updated meta-analysis. *Journal of Product Innovation Management* 29(S1): 21–37. doi: 10.1111/j.1540-5885.2012.00964.x

Isaacson, W. 2011. *Steve Jobs: The Exclusive Biography*. New York, NY: Simon & Schuster.

Kock, A., and Gemünden, H. G. 2016. Antecedents to decision-making quality and agility in innovation portfolio management. *Journal of Product Innovation Management* 33(6): 670–686. doi: 10.1111/jpim.12336

Matheson, D., Matheson, J. E., and Menke, M. 1994. Making excellent R&D decisions. *Research Technology Management* 37(6): 21–24. doi: 10.1080/08956308.1994.11671006

Meifort, A. 2016. Innovation portfolio management: A synthesis and research agenda. *Creativity and Innovation Management* 25(2): 251–269. doi: 10.1111/caim.12109

McNally, R. C., Cavusgil, E., and Calantone, R. J. 2010. Product innovativeness dimensions and their relationships with product advantage, product financial performance, and project protocol. *Journal of Product Innovation Management* 27(1): 991–1006. doi: 10.1111/j.1540-5885.2010.00766.x

Mills, M. 2007. Implementing a stage-gate process at Procter & Gamble. In *Stage-Gate Leadership Summit Conference*. St. Petersburg Beach, FL.

Mitchell, R., Phaal, R., Athanassopoulou, N., Farrukh, C., and Rassmussen, C. 2022. How to build a customized scoring tool to evaluate and select early-stage projects. *Research-Technology Management* 65(3): 27–38. doi: 10.1080/08956308.2022.2026185

Project Management Institute. 2021. *Measuring What Matters*. https://www.pmi.org/-/media/pmi/documents/public/pdf/learning/thought-leadership/measuring_what_matters_report.pdf

Product Development and Management Association. 2013. *The PDMA Handbook of New Product Development*, 3rd edition, edited by Kenneth B. Kahn Hoboken, NJ: Wiley, Glossary: 461.

Product Development and Management Association. 2023. "New products: what separates the winners from the losers and what drives success," by R. G. Cooper, Chapter 1 in: *The PDMA Handbook of Innovation and New Product Development*, 4th ed., edited by Ludwig Bstieler and Charles H. Noble. Hoboken, NJ: Wiley.

Reis, E. 2011. *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*. New York, NY: Crown.

Sandemeier, P., Morrison, P. D., and Gassman, O. 2010. Integrating customers in product innovation: Lessons from industrial development contractors and in-house contractors in rapidly changing customer markets. *Creativity and Innovation Management* 19(2): 89–106. doi: 10.1111/j.1467-8691.2010.00555.x

Thomke, S., and Reinertsen, D. 2012. Six myths of product development. *Harvard Business Review* 90(5): 84–94. https://hbr.org/2012/05/six-myths-of-product-development

Wang, Y., Zhang, H., and Song, M. 2020. Does big data–embedded new product development influence project success? *Research-Technology Management* 63(4): 35–42. doi: 10.1080/08956308.2020.1762447

Wilkinson, S. 2020. Armstrong *ACOUSTIBuilt—A Case History in Using Agile Methods & Tools*. https://isbm.com/wp-content/uploads/pdf/03_Day1_SWilkinson_Armstrong%20and%20Agile-Penn%20State-ISBM-Feb2020-Final-Feb-6-7.pdf