Chapter **Seven**

Choosing Innovation Projects

Where Should We Focus Our Innovation Efforts? An Exercise.[a]

Technological change can make the world feel very uncertain—how can we know what customers will want, or competitors will do, in the future? The future of a technology, however, is not as unknowable as it might seem. If you can get the big picture of the dimensions along which a technology is improving, and where the big payoffs are still yet to be reaped, you can gain insight into where the next big breakthroughs are likely to, or should, be. This can help managers understand where to focus their R&D efforts, and to anticipate the moves of competitors.

The story of Sony's SACD provides a great example. In the mid-1990s, the compact disc market was approaching saturation and both the consumer electronics and recording industries were eager to introduce a next-generation audio format that would usher in a new era of growth. In 1996, Hitachi, JVC, Mitsubishi, Toshiba, Universal Music Group, Time Warner, and others formed a consortium to back a new standard, DVD audio, that offered superior fidelity and surround sound. The plan was twofold: to drive consumers to upgrade their players and libraries and to do an end-run around Sony and Philips which owned the compact disc standard and extracted a licensing fee for every CD and player sold.

Sony and Philips, however, were not going to go down without a fight. They counterattacked with their own new format, Super Audio CD, an extension of the old one which would have allowed them to control the royalties for the new discs and players. The industry gave a collective groan; manufacturers, distributors, and consumers all stood to lose big if they placed bets on the wrong format. Nonetheless, Sony launched the first super-audio players in late 1999; DVD audio players began to hit the market in mid-2000 and prices for both rapidly fell and converged. A costly format war seemed inevitable.

You may be scratching your head at this point, wondering why you'd never heard about this format war. What happened? MP3 happened. While the consumer electronics giants were pursuing new heights in audio fidelity, an algorithm that slightly *depressed* fidelity in exchange for reduced audio file size was taking off. Soon after the file-sharing platform Napster launched in 1999, consumers were downloading free music files by the millions and Napster-like services were sprouting up like weeds.

It's easy to think that Sony, Philips, and the DVD Audio consortium just got unlucky. After all, who could have predicted the disruptive arrival of MP3? How could the consumer electronics giants have known that a format trajectory of ever-increasing fidelity would be overtaken by a technology with *less* fidelity? Actually, they all should have seen that the next big breakthrough success was far more likely to be about portability and selection than fidelity.

Here is an exercise that can help you get the "big picture" of technology evolution in an area, and to prioritize innovation investments.

Step One: Identify the Dimensions

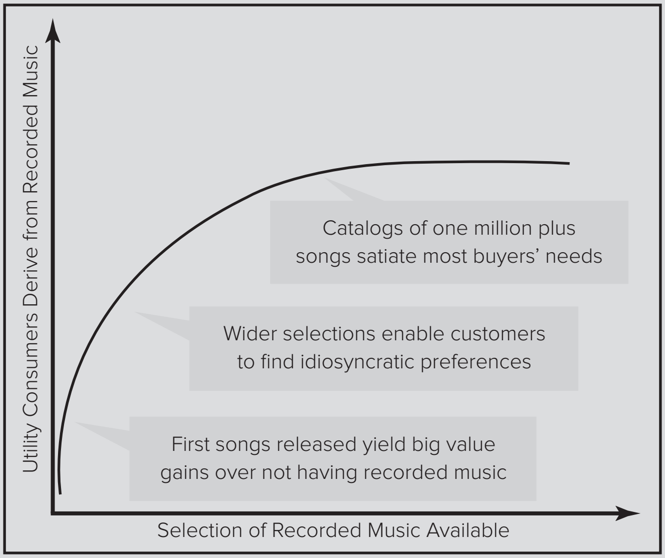
Technologies typically progress along several dimensions at once. For example, computers became faster and smaller in tandem; speed was one dimension, size another. Developments in any dimension come with specific costs and benefits and have measurable and changing utility to customers. Identifying the key dimensions that a technology has progressed along is the first step in predicting its future.

One of the best ways to identify these dimensions is to trace the technology's path to date, and for each major change in the technology's form, identify the dimensions that were affected. The further back in time you can go, to the most primitive way of fulfilling the need the technology meets, the easier it will be to see the high-level dimensions along which the technology has changed.

For example, prior to the phonograph, people could hear music or a speech only when and where it was performed. The first phonographs introduced in the 1800s *desynchronize* the time and place of a performance so that it could be heard at any-time, anywhere. That was a huge accomplishment. Those phonographs, however, were cumbersome. The sound quality was "tinny" and music selection was extremely limited. When Emile Berliner introduced flat disc-shaped records, it dramatically increased the sound *fidelity,* while dramatically lowering the *cost,* which in turn led to a huge increase in the *selection* of music available. Later, in the 1960s eight-track tape cartridges would bring *portability* to recorded music. Cassette tapes rose to dominance in the 1970s further enhancing *portability,* but also offering *customizability* for the first time—the ability to record your own music, speeches, and more. Then in 1982, Sony and Philips introduced the compact disc standard which offered greater *fidelity* than cassette tapes and rapidly became the dominant format. Tracing this history thus reveals six key dimensions that have driven the evolution of audio format technology: *De synchronization, cost, fidelity, selection, portability, and customizability.*

Now repeat this process in the area you are interested, starting far back in the past and following the path of the technology forward in time. Look for each major inflection point. Try to identify the three to five most important high-level dimensions along which the technology has evolved. Getting to a high level of

FIGURE 1
A Parabolic Utility Curve for the Selection of Music Available



a dimension is important because it helps you to see the big picture rather than being caught up in the details.

Step Two: Where Are We on the Utility Curve for Each Dimension?

For each dimension, we now want to determine the shape of the utility curve—the plot of the value customers derive from a technology according to its performance on a given dimension—and where we currently are on the curve. This will help reveal where the most opportunity for improvement lies.

For example, the history of audio formats suggests that the *selection* of music available has a concave parabolic utility curve: utility increases with increasing selection, but at a decreasing rate, and not indefinitely (see Figure 1). When there's little music to choose from, even a small increase in *selection* significantly enhances utility. When the first phonographs appeared, for example, there were few recordings to play on them. As more recordings became available, customers eagerly bought them, and the appeal of owning a player grew dramatically. Over the ensuing decades, selection grew exponentially and the utility curve ultimately began to flatten; people still valued new releases, but each new recording added less additional value. Today digital music services like iTunes, Amazon Prime Music, and Spotify offer tens of millions of songs. With this virtually unlimited selection, most customers' appetites are sated—and we are probably approaching the top of the curve.

Now let's consider the *fidelity* dimension, the primary focus of Super Audio CD and DVD audio. Fidelity also likely has a concave parabolic utility curve. The first phonographs had awful fidelity; music sounded thin and tinny, though it was still a remarkable benefit to be able to hear any recorded music at all. The early improvements in fidelity that records offered made a big difference in people's enjoyment of music. Then along came compact discs which offered even more fidelity, though many people felt that vinyl records were "good enough" and some even preferred their "warmth." The fidelity curve was already leveling out when Sony, Philips, and the DVD Audio consortium introduced their new formats in the early 2000s. Super Audio CD and DVD Audio offered significantly higher fidelity than the compact disc. For example, whereas CDs have a frequency range up to about 20 thousand cycles per second (kHz), the new formats offered ranges that reached 100 kHz. That's an impressive high end—but as human hearing peaks out at about 20 kHz, only the family dog was likely to appreciate it. In 2007, the Audio Engineering Society released results of a year-long trial assessing how well subjects (including professional recording engineers) could detect the difference between Super Audio and regular CDs. Subjects correctly identified the Super Audio CD format only half the time, no better than if they'd been simply guessing!

Had the companies analyzed the utility curve for *fidelity* they could have seen that there was little payoff for investing in this dimension. Meanwhile, even a cursory look at the *portability, selection,* and *cost* curves would have revealed the opportunity there, and MP3 offered big payoffs on all three.

Step Three: Where Should We Invest Our Money and Effort?

Using a matrix like the one below can help us assess which technology-development investments are likely to yield the biggest bang for the buck (see Figure 2). First, list the performance dimensions you've identified as most important to customers. Then, score each dimension on a scale of 1 to 5 in three areas: importance to customers (1 means "not important" and 5 means "very important"); room for improvement (i.e., how far we are from the utility curve flattening out, where 1 means "minor opportunity for improvement" and 5 means "large opportunity for improvement"); and ease of improvement (1 means "very difficult" and 5 means "very easy").

For example, the scores created by a company that makes glucose-monitoring devices are shown in the matrix (Figure 2). The feature most important to customers is *reliability*—reliable measures can mean life or death for a patient. However, existing devices (mostly finger-prick devices that test a drop of blood with a portable reader) are already very reliable, and thus scored low

FIGURE 2
Ranking Areas of Focus

Rank	Dimension	Importance to Buyers (1–5 scale)	Room for Improvement (1–5 scale)	Ease of Improvement (1–5 scale)	Total Score
	Cost	4	2	2	8
	Comfort	4	4	3	11
	Reliability	5	1	1	7
	Ease of use	3	2	3	8

on the "room for improvement" measure. They are also fairly *easy to use,* and reasonably *low cost.* However, they are uncomfortable. *Comfort* is a dimension that is ranked highly by users (though not as high as *reliability*), yet is much further from the optimum. Both *comfort* and *ease of use* are modestly difficult to improve (scoring 3s in this example), yet because *comfort* is both more important to customers than *ease of use,* and further from the optimum, *comfort* ends up with a significantly higher total score. The team that provided the scores for this example ended up proposing that the company develop a patch worn on the skin that would detect glucose levels based on sweat that would be sent via Bluetooth to the user's smartphone.

Notably, we can adjust the scale of the scores to reflect the organization's objectives (e.g., a cash-strapped firm might weigh "ease of improvement" higher, thus we could change the scale to 1–10), and we can repeat this analysis for different market segments that have different ratings for the importance of a dimension or its room for improvement. For example, we could divide the glucose-monitoring device market into a market for children's devices versus adults' devices. *Comfort* and *ease of use* are particularly important for glucose monitors for children. We might thus score *comfort* and *ease of use* as 5 for "importance to customer" in the children's device market, indicating that in this market, these dimensions are often more important than cost.

Shifting the Organization's Focal Point

This exercise can help managers broaden their perspective on their industry, and shift their focus from "this is what we do" to "this is where our market is (or should be) heading." It can also help overcome the bias and inertia that tend to lock an organization's focus on technology dimensions that are less important to consumers than they once were. To be truly innovative, it is not enough for organizations to merely improve what they are doing; they need to be able to look into the future and identify *what could be done* in the industry that is better—much better—than what the industry is doing today.

Discussion Questions

1. Why did the consumer electronic giants invest so much in developing audio technology that exceeded the hearing capacity of humans?
2. Can you think of other companies or industries that are currently investing in technology dimensions where the utility payoff of improving the technology has flattened?
3. Can you come up with an example of a firm that would likely weight "importance to customers" much higher than "ease of improvement"? Can you come up with an example of a firm that would likely weight "ease of improvement" much higher than "importance to customers"?

[a] Adapted from Schilling, M. A., "What's Your Best Innovation Bet?" *Harvard Business Review* (July–August 2017) 86–93.

OVERVIEW

capital rationing
The allocation of a finite quantity of resources over different possible uses.

Developing innovative new products and services is expensive and time-consuming. It is also extremely risky—most studies have indicated that the vast majority of development projects fail. Firms have to make difficult choices about which projects are worth the investment, and then they have to make sure those projects are pursued with a rigorous and well-thought-out development process. In this chapter, we will explore the various methods used to evaluate and choose innovation projects. The methods range from informal to highly structured, and from entirely qualitative to strictly quantitative. We will start by considering the role of **capital rationing** in the R&D investment decision, and then we will cover various methods used to evaluate projects including strictly quantitative methods, qualitative methods, and approaches that combine quantitative and qualitative techniques.

THE DEVELOPMENT BUDGET

R&D intensity
The ratio of R&D expenditures to sales.

While many project valuation methods seem to assume that all valuable projects will be funded, most firms face serious constraints in capital and other resources, forcing them to choose between multiple valuable projects (or obtain external financing as discussed in the Theory in Action section on Financing New Technology Ventures). Many firms use a form of *capital rationing* in formulating their new product development plans. Under capital rationing, the firm sets a fixed research and development budget (often some percentage of the previous year's sales), and then uses a rank ordering of possible projects to determine which will be funded. Firms might establish this budget on the basis of industry benchmarks or historical benchmarks of the firm's own performance. To provide a sense of what firms in different industries spend on R&D, Figure 7.1 shows the 10 industries with the highest **R&D intensity** (R&D expenditures as a percentage of sales), based on North American publicly held firms in 2016. Some industries (notably drugs, special industry machinery, and semiconductors and electronic components) spend considerably more of their revenues on R&D than other industries, on average.

There is also considerable variation within each of the industries in the amount that individual firms spend. For example, as shown in Figure 7.2, Merck's R&D intensity is significantly higher than the average for drug producers (25 percent versus 20 percent), whereas Pfizer's is somewhat lower than the industry average (16 percent versus 20 percent). Figure 7.2 also reveals the impact of firm size on R&D budgets: Whereas the absolute amount spent on R&D at Volkswagen surpasses the R&D spend at most other firms by a large amount, Volkswagen's R&D intensity is relatively low due to its very large sales base.

The rank ordering used in capital rationing may be established by any number of methods, including quantitative methods, such as discounted cash flow analysis or options analysis, or qualitative methods, such as screening questions and portfolio mapping, or a combination of multiple methods. Knowing the requirements, strengths, and weaknesses of each method helps managers make sound decisions about which valuation techniques to employ.

FIGURE 7.1
Top 10 Industries (Three Digit SIC) by R&D Intensity, 2016

Based on Compustat data; only industries with 20 or more firms were included. Sales and R&D were aggregated up to the industry level prior to calculating R&D intensity to minimize the effect of large firm-level outliers.

Rank	Three Dig. SIC Code	Industry Description	Number of Publicly Held Firms	Industry R&D Spend ($millions)	Industry Revenues ($millions)	Industry R&D Intensity (R&D/Sales)
1	2830	Drugs, biological products, and diagnostics	782	$137,560	$ 704,234	0.20
2	3550	Special industry machinery	38	$ 4504	$ 35,711	0.13
3	3670	Semiconductors and electronic components	191	$ 48,136	$ 439,169	0.11
4	7370	Software and computer programming services	633	$ 89,310	$ 871,904	0.10
5	3840	Medical equipment	211	$ 12,046	$ 151,316	0.08
6	3660	Communication equipment	79	$ 22,624	$ 306,619	0.07
7	3820	Measuring equipment and instruments	83	$ 7996	$ 109,967	0.07
8	3570	Computers and peripherals	81	$ 25,580	$ 354,589	0.07
9	5960	Nonstore retailers	41	$ 16,120	$ 245,297	0.07
10	3710	Motor vehicles and motor vehicle equipment	82	$ 70,509	$1,691,357	0.04

Source: Based on Compustat data.

FIGURE 7.2
Top 20 Global R&D Spenders, 2016

Source: Data from Compustat.

Company	Sales ($millions)	R&D ($millions)	R&D Intensity (R&D/Sales)
AMAZON.COM	$135,987	$16,085	12%
ALPHABET	$ 90,272	$13,948	15%
INTEL	$ 59,387	$12,740	21%
VOLKSWAGEN	$231,205	$12,144	5%
MICROSOFT	$ 85,320	$11,988	14%
ROCHE HOLDING	$ 51,807	$11,350	22%
MERCK & CO	$ 39,807	$10,124	25%
APPLE	$215,091	$10,045	5%
TOYOTA MOTOR	$252,652	$ 9390	4%
JOHNSON & JOHNSON	$ 71,890	$ 9124	13%
NOVARTIS	$ 48,518	$ 9039	19%
PFIZER	$ 52,824	$ 8375	16%
GENERAL MOTORS	$166,380	$ 8100	5%
FORD MOTOR	$151,800	$ 7300	5%
CISCO SYSTEMS	$ 49,247	$ 6296	13%
FACEBOOK	$ 27,638	$ 5919	21%
ASTRAZENECA	$ 23,408	$ 5890	25%
HONDA MOTOR CO	$129,880	$ 5840	4%
ORACLE	$ 37,047	$ 5787	16%
IBM	$ 79,920	$ 5751	7%

Theory in Action Financing New Technology Ventures

While large firms can fund innovation projects internally, new technology start-ups must often obtain external financing. This can sometimes be daunting. Because technology start-ups often have both an unproven technology and an unproven business concept (and sometimes an unproven management team), they typically face a much higher cost of capital than larger competitors, and their options for obtaining capital can be very limited. In the first few stages of start-up and growth, entrepreneurs may have to turn to friends, family, and personal debt. Start-ups might also be able to obtain some initial funding through government agencies. If the idea and the management team seem promising enough, the entrepreneur can tap "angel investors" and venture capitalists as sources of both funds and mentoring.

FAMILY, FRIENDS, AND CREDIT CARDS

When a new venture is starting out, often the technology and/or management is unproven, making the venture appear very risky. In this stage, entrepreneurs must often rely on friends and family members who are willing to provide initial funding either in the form of a loan or an exchange for equity in the company. Alternatively, the entrepreneur may try to obtain debt financing from a local bank. A very large number of start-ups are actually funded with credit cards, resulting in a very high rate of interest!

GOVERNMENT GRANTS AND LOANS

Some new ventures obtain start-up funds from government sources. In the United States, the Small Business Administration (SBA) is designed to foster entrepreneurship and innovation by administering grants, loans, and venture capital programs from many different federal agencies including the Department of Commerce, Department of Agriculture, Department of Energy, NASA, and others. Similarly, in the United Kingdom, the Enterprise Fund administers a series of programs designed to fund small- to medium-size technology firms, and in Germany there are more than 800 federal and state government programs established to finance new firms.[a]

ANGEL INVESTORS

Angel investors are private investors who fund projects without utilizing a venture capital limited partnership structure. They are often wealthy individuals who have been very successful in business, and who enjoy the thrill of vicarious entrepreneurship afforded by investing in—and sometimes mentoring—start-up firms. Angels typically fund projects that are $1 million or less. While angel investors lose money in a significant share of their investments, those investments that pay off can earn very high returns. Angels are usually not listed in public directories, but are identified through professional networks (e.g., through one's former colleagues, professors, or lawyers). A large number of start-ups obtain "seed-stage" (before there is a real product or company organized) financing from angel investors. While it is difficult to get data on angel investing because most of the transactions are not publicly reported, estimates from the Center for Venture Research indicate that angel investors funded 64,380 entrepreneurial ventures in 2016 for a total of $21.3 billion (an average of $330,000 per deal).

VENTURE CAPITAL

For projects that require more than $1 million, entrepreneurs often turn to venture capital, either from independent venture capital firms or from corporate venture capital sources.

Independent venture capital firms manage a pool of funds that they invest in projects they believe to have rapid growth potential. Many venture capital firms specialize in particular industries, making them better able to evaluate the potential of start-ups in that industry. They also prefer to make deals with firms within driving distance so that they can have frequent face-to-face contact.[b]

The venture capital funds are likely to be provided in a complex debt-equity hybrid contract that essentially looks more like equity if the firm performs well, or debt if the firm performs poorly.[c] If and when the business is successful, the venture capitalist can cash out of the investment by negotiating an initial public offering or a buyout of the company by another firm. Venture capitalists are very selective and reject the vast majority of proposals considered. However, for those projects that are funded, the support of the venture capitalist provides a number of valuable benefits including credibility among other investors (and thus better

continued

concluded

access to capital) and mentoring. While some venture capitalists specialize in providing seed-stage funding, venture capitalists are more likely to provide funding during early stages—after the company has been organized and the product has shown early signs of success, but before it is able to sustain its development activities and growth through its own revenues. According to estimates by Crunchbase, in 2017 venture capitalists invested about $213.6 billion on 22,700 deals globally. The most prolific venture capital firm, Sequoia Capital, lead 70 venture rounds in 2017.

Corporate venture capital is provided by firms that wish to take a minority equity stake in another firm's technology development, often to gain access to cutting-edge technology that they may wish to develop further should it prove technically and commercially promising. Such firms may establish an internal venturing group that is closely tied to the firm's own development operations, or they may create a dedicated external fund that has more independence from the firm's own operations.[d] The benefit of the former structure is that the firm should be better able to use its own expertise and resources to help the new venture succeed. However, under this structure, the entrepreneur may have concerns about the larger firm expropriating the entrepreneur's proprietary technology. Under the latter structure, the independence of the external venture fund provides some reassurance that the entrepreneur's technology will not be stolen, but it also limits the ability of the entrepreneur to leverage any of the larger firm's nonfinancial resources.[e] According to CB Insights, there were 1791 corporate venture capital deals globally in 2017, totaling $31.2 billion (averaging over $17 million per deal). According to CB Insights, the most active corporate venture capital programs in 2017 were GV (formerly Google Ventures), Intel Capital, Salesforce Ventures, Qualcomm Ventures, GE Ventures, Legend Capital, Microsoft Ventures, K Cube Ventures, Fosun RZ Capital, and Samsung Ventures.

[a] B. Hall, "The Financing of Research and Development," *Oxford Review of Economic Policy* 18 (2002), pp. 35–51.
[b] Gompers, P. A., and J. Lerner, *The Venture Capital Cycle* (Boston: MIT Press, 2004); Pahnke, E. C., R. Katila, and K. Eisenhardt, "Who Takes You to the Dance? How Partners' Institutional Logics Influence Innovation in Young Firms," *Administrative Science Quarterly,* 60 (2015):596–633.
[c] Hall, "The Financing of Research and Development."
[d] P. A. Gompers, "Corporations and the Financing of Innovation: The Corporate Venturing Experience," *Economic Review—Federal Reserve Bank of Atlanta* 87, no. 4 (2002), pp. 1–18.
[e] G. Dushnitsky, "Limitations to External Knowledge Acquisition: The Paradox of Corporate Venture Capital," doctoral dissertation, New York University, 2003.

QUANTITATIVE METHODS FOR CHOOSING PROJECTS

net present value (NPV)
The discounted cash inflows of a project minus the discounted cash outflows.

internal rate of return (IRR)
The rate of return yielded by a project, normally calculated as the discount rate that makes the net present value of an investment equal zero.

Quantitative methods of analyzing new projects usually entail converting projects into some estimate of future cash returns from a project. Quantitative methods enable managers to use rigorous mathematical and statistical comparisons of projects, though the quality of the comparison is ultimately a function of the quality of the original estimates. The accuracy of such estimates can be questionable—particularly in highly uncertain or rapidly changing environments. The most commonly used quantitative methods include discounted cash flow methods and real options.

Discounted Cash Flow Methods

Many firms use some form of discounted cash flow analysis to evaluate projects. Discounted cash flows are quantitative methods for assessing whether the anticipated future benefits are large enough to justify expenditure, given the risks. Discounted cash flow methods take into account the payback period, risk, and time value of money. The two most commonly used forms of discounted cash flow analysis for evaluating investment decisions are **net present value (NPV)** and **internal rate of return (IRR)**. Both methods rely on the same basic discounted cash flow mechanics, but they look at the problem from different angles. NPV asks, "Given a particular level of expenditure, particular level(s) and rate of cash inflows, and a discount rate, what is this project worth today?" IRR asks instead, "Given a particular level of expenditure and particular level(s) and rate of cash inflows, what rate of return does this project yield?" For either method, managers must use estimates of the size and timing of expenditures and cash inflows. Both methods enable the decision maker to incorporate some basic measure of risk. For example, riskier projects may be examined by using a higher discount factor in NPV analysis. Managers also often calculate discounted cash flow measures using best-case and worst-case cash flow estimates.

Net Present Value (NPV)

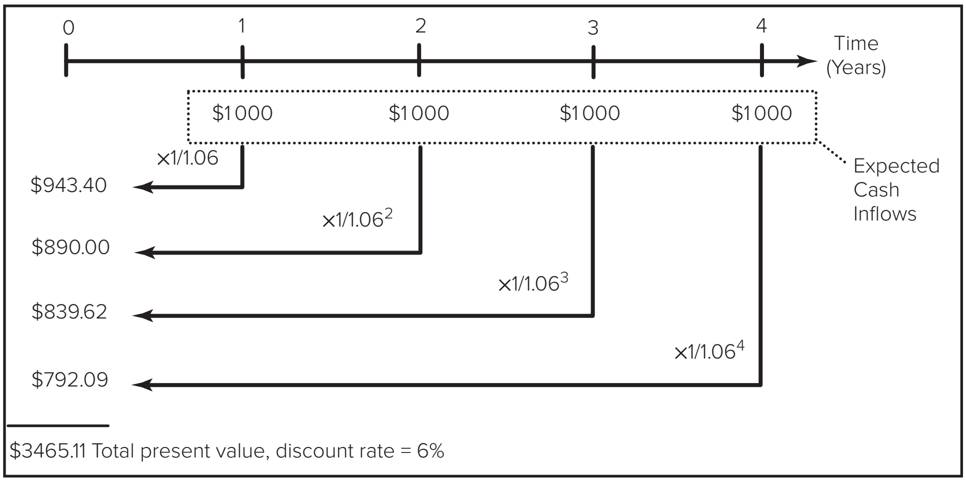
To calculate the NPV of a project, managers first estimate the costs of the project and the cash flows the project will yield (often under a number of different "what if" scenarios). Costs and cash flows that occur in the future must be discounted back to the current period to account for risk and the time value of money. The present value of cash inflows can then be compared to the present value of cash outflows:

$$\text{NPV} = \text{Present value of cash inflow} - \text{Present value of cash outflows}$$

If this value is greater than 0, then the project generates wealth, given the assumptions made in calculating its costs and cash inflows.

To find the present value of cash inflow and outflows, each cash flow must be discounted back to the current period using a discount rate (see Figure 7.3). If there is a single expenditure at the beginning of the project (year 0), the original expenditure can be compared directly to the present value of the future expected cash flows. In the example in Figure 7.3, the present value of the future cash flows (given a discount rate of 6 percent) is $3465.11. Thus, if the initial cost of the project were less than $3465.11, the net present value of the project is positive. If there are cash outflows for

FIGURE 7.3
Example of Present Value of Future Cash Flows



multiple periods (as is common with most development projects), those cash outflows would have to be discounted back to the current period.

If the cash inflows from the development project were expected to be the same each year (as they were in Figure 7.3), we can use the formula for calculating the present value of an annuity instead of discounting each of the cash inflows individually. This is particularly useful when cash inflows are expected for many years. The present value of C dollars per period, for t periods, with discount rate r is given by the following formula:

$$\text{Annuity present value} = C \times \frac{1 - \{1/(1+r)^{1}\}}{r}$$

This amount can then be compared to the initial investment. If the cash flows are expected in perpetuity (forever), then a simpler formula can be used:

$$\text{Perpetuity present value} = C \times 1/r$$

discounted payback period
The time required to break even on a project using discounted cash flows.

The present value of the costs and future cash flows can also be used to calculate the **discounted payback period** (i.e., the time required to break even on the project using discounted cash flows). Suppose for the example above, the initial investment required was \$2000. Using the discounted cash inflows, the cumulative discounted cash flows for each year are:

Year	Cash Flow
1	\$ 934.40
2	1833.40
3	2673.02
4	3465.11

Thus, the investment will be paid back sometime between the end of year 2 and the end of year 3. The accumulated discounted cash flows by the end of year 2 are \$1833.40, so we need to recover \$166.60 in year 3. Since the discounted cash flow expected for year 3 is \$839.62, we will have to wait \$166.60/\$839.61 ≈ 0.20 of a year. Thus, the payback period is just over two years and two months.

Internal Rate of Return (IRR)

The internal rate of return of a project is the discount rate that makes the net present value of the investment zero. Managers can compare this rate of return to their required return to decide if the investment should be made. Calculating the IRR of a project typically must be done by trial and error, substituting progressively higher interest rates into the NPV equation until the NPV is driven down to zero. Calculators and computers can perform this trial and error. This measure should be used cautiously, however; if cash flows arrive in varying amounts per period, there can be multiple rates of return, and typical calculators or computer programs will often simply report the first IRR that is found.

Both net present value and internal rate of return techniques provide concrete financial estimates that facilitate strategic planning and trade-off decisions. They explicitly consider the timing of investment and cash flows, and the time value of money and risk. They can make the returns of the project seem unambiguous, and managers may find them very reassuring. However, this minimization of ambiguity may be deceptive; discounted cash flow estimates are only as accurate as the original estimates of the profits from the technology, and in many situations it is extremely difficult to anticipate the returns of the technology. Furthermore, such methods discriminate heavily against projects that are long term or risky, and the methods may fail to capture the strategic importance of the investment decision. Technology development projects play a crucial role in building and leveraging firm capabilities, and creating options for the future. Investments in new core technologies are investments in the organization's capabilities and learning, and they create opportunities for the firm that might otherwise be unavailable.[1] Thus, standard discounted cash flow analysis has the potential to severely undervalue a development project's contribution to the firm. For example, Intel's investment in DRAM technology might have been considered a total loss by NPV methods (Intel exited the DRAM business after Japanese competitors drove the price of DRAM to levels Intel could not match). However, the investment in DRAM technology laid the foundation for Intel's ability to develop microprocessors—and this business has proved to be enormously profitable for Intel. To better incorporate strategic implications in the new product development investment decision, some managers and scholars have recently begun promoting the idea of treating new product development decisions as real options, as described below.

Real Options

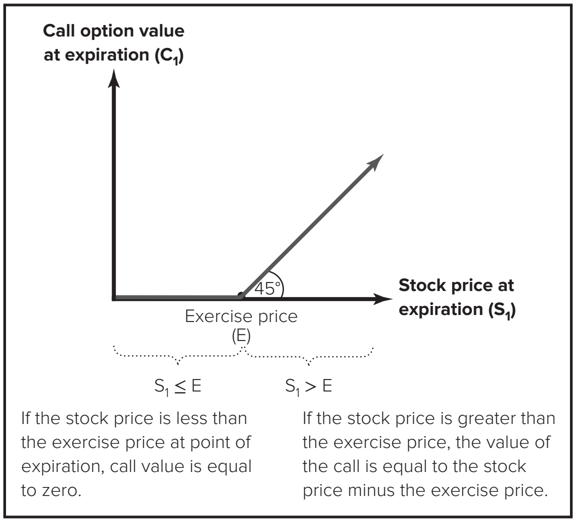
When a firm develops new core technologies, it is simultaneously investing in its own learning and in the development of new capabilities. Thus, development projects can create valuable future opportunities for the firm that would otherwise be unavailable.[2] Even development projects that appear unsuccessful (as Intel's DRAM discussed above) may prove to be very valuable when they are considered from the perspective of the options they create for the future of the firm. Some managers and scholars have begun arguing that new product development decisions should be evaluated as **real options**.

real options
The application of stock option valuation methods to investments in nonfinancial assets.

To understand real options, it is first useful to consider the financial model upon which they are based—stock options. A call option on a stock enables an investor to purchase the right to buy the stock at a specified price (the *exercise price*) in the future. If, in the future, the stock is worth more than the exercise price, the holder of the option will typically exercise the option by buying the stock. If the stock is worth more than the exercise price plus the price paid for the original option, the option holder makes money on the deal. If the stock is worth less than the exercise price, the option holder will typically choose not to exercise the option, allowing it to expire. In this case, the option holder loses the amount of money paid for the initial option. If, at the time the option is exercised, the stock is worth more than the exercise price but not more than the exercise price plus the amount paid for the original option, the stockholder will typically exercise the option. Even though the stockholder loses money on the deal (some portion of the price paid for the original option), he or she loses less than if he or she allowed the option to expire (the entire price paid for the original option).

In *real options,* the assets underlying the value of the option are nonfinancial resources.[3] An investor who makes an initial investment in basic R&D or in

FIGURE 7.4
The Value of a Call Option at Expiration



breakthrough technologies is, it is argued, buying a real call option to implement that technology later should it prove to be valuable:

- The cost of the R&D program can be considered the price of a call option.
- The cost of future investment required to capitalize on the R&D program (such as the cost of commercializing a new technology that is developed) can be considered the exercise price.
- The returns to the R&D investment are analogous to the value of a stock purchased with a call option.[4]

As shown in Figure 7.4, the value of a call stock option is zero as long as the price of the stock remains less than the exercise price. If the value of the stock rises above the exercise price, however, the value of the call rises with the value of the stock, dollar for dollar (thus the value of the call rises at a 45-degree angle).[5]

Options are valuable when there is uncertainty, and because technology trajectories are uncertain, an options approach may be useful. Though there has not yet been much empirical work in the area, several authors have developed methodologies and applications of options analysis to valuing technology development investments.[6] Also, some evidence shows that an options approach results in better technology investment decisions than a cash flow analysis approach.[7]

Other authors, however, warn against liberal application of the approach, pointing out that technology investment scenarios often do not conform to the same capital market assumptions upon which the approach is based.[8] For instance, implicit in the value of options is the assumption that one can acquire or retain the option for a small price, and then wait for a signal to determine if the option should be exercised.[9] While this assumption might hold true for an outside firm investing venture capital in another firm's innovation effort, it would be rare for this assumption to hold for a company investing in its own development efforts. In the case of a firm undertaking solo new product development, it may not be possible to secure this option at a small price; it may require full investment in the technology before a firm can determine if the technology will be successful.[10] Furthermore, while the value of a stock is independent of the call holder's behavior (i.e., the call holder can simply wait and observe whether the value of the stock rises or falls), the value of an R&D investment is not independent of the investor's behavior. A firm's degree of investment, its development capabilities, its complementary assets, and its strategies can all significantly influence the future returns of the development project.[11] Therefore, rather than simply waiting and observing the value of the investment, the investor is an active driver of the value of the investment.

DISADVANTAGES OF QUANTITATIVE METHODS

Quantitative methods for analyzing potential innovation projects can provide concrete financial estimates that facilitate strategic planning and trade-off decisions. They can explicitly consider the timing of investment and cash flows and the time value of money and risk. They can make the returns of the project seem unambiguous, and managers may find them very reassuring. However, this minimization of ambiguity may be deceptive; discounted cash flow estimates are only as accurate as the original estimates of the profits from the technology, and in many situations, it is extremely difficult to anticipate the returns of the technology. As noted by Professor Freek Vermeulen, author of *Business Exposed*, one of the most common mistakes managers make in their innovation strategy is to insist on "seeing the numbers"—for truly innovative products, it is impossible to reliably produce any numbers. It is very difficult to compute the size of a market that does not yet exist.[12] Furthermore, such methods discriminate heavily against projects that are long term or risky, and the methods may fail to capture the strategic importance of the investment decision. Technology development projects play a crucial role in building and leveraging firm capabilities and creating options for the future. Investments in new core technologies are investments in the organization's capabilities and learning, and they create opportunities for the firm that might otherwise be unavailable.

QUALITATIVE METHODS FOR CHOOSING PROJECTS

Most new product development projects require the evaluation of a significant amount of qualitative information. Many factors in the choice of development projects are extremely difficult to quantify, or quantification could lead to misleading results. Almost all firms utilize some form of qualitative assessment of potential projects, ranging from informal discussions to highly structured approaches.

Screening Questions

As a starting point, a management team is likely to discuss the potential costs and benefits of a project, and the team may create a list of screening questions that are used to structure this discussion. These questions might be organized into categories such as the role of the customer, the role of the firm's capabilities, and the project's timing and cost.[13] Some examples are provided below:

Role of Customer

Market

- Who are the most likely customers of the new product?
- How big is this market? Are there other likely markets for the product?
- What type of marketing will be required to create customer awareness?

Use

- How will customers use the product?
- What new benefits will the product provide the customer?
- What other products are customers likely to consider as substitutes for this product?

Compatibility and Ease of Use

- Will the product be compatible with the customer's existing complements?
- Will the product require significant new learning on the part of the customer?
- How will the customer perceive the product's ease of use?
- Will the product require the customer to bear other costs?

Distribution and Pricing

- Where will the customer buy the product?
- Will the product require installation or assembly?
- How much are customers likely to be willing to pay for the product?

Role of Capabilities

Existing Capabilities

- Does the new project leverage the firm's core competencies or sources of sustainable competitive advantage?
- Will the project render some of the firm's existing competencies obsolete or cannibalize existing products? If so, does the firm have a transition strategy to handle possible cash flow implications?
- Does the firm have the necessary manufacturing capabilities, and if not, will those capabilities be developed in-house or acquired externally (e.g., outsourcing)?
- Will the firm need to hire employees with new skills?

Competitors' Capabilities

- Do one or more competitors have better capabilities for developing this project?
- If the company does not develop this technology, are competitors likely to?
- Will the company be able to protect its intellectual property through patents, copyright, trademarks, or trade secrets?
- Should the firm seek to form a collaboration with a potential competitor?

Future Capabilities

- Will the project help the firm build new capabilities that will allow it to achieve its strategic intent?
- What other products/markets will the new capabilities enable the firm to develop?
- Is this project a platform that will lead to a family of new products?

Project Timing and Cost

Timing

- How long will the project take to complete?
- Is the firm likely to be first to market? Is pioneering the technology a desirable strategy?
- Is the market ready for the product? (For example: Are enabling and complementary technologies well developed? Will customers perceive the value of the technology?)
- If the firm misses its target deadlines, what impact will this have on the potential value of the project?
- Are there already appropriate suppliers and distribution channels?

Cost Factors

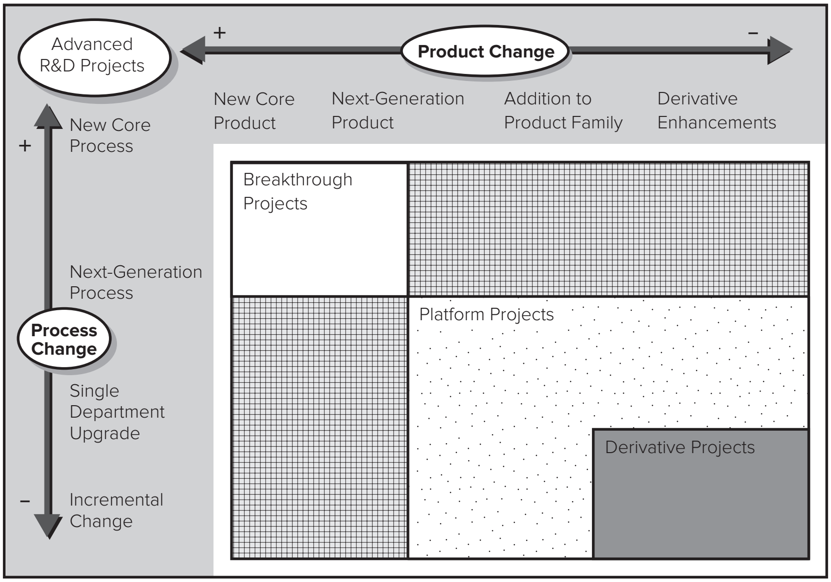
- How much will the project cost? What is the potential variability in these costs?
- What will the manufacturing costs be? At what rate are these costs expected to decline with experience?
- Will the firm need to bear other costs related to customer adoption (e.g., production of complements, installation, technical support, etc.)?

After creating a list of questions, managers can use the questions to structure debate about a project, or they can create a scoring mechanism (such as a scaled response to each question such as "Project fits closely with existing competencies" to "Project fits poorly with existing competencies") that can then be weighted according to importance and used in subsequent analysis.

While screening questions such as the ones above do not always provide concrete answers about whether or not to fund a project, they enable a firm to consider a wider range of issues that may be important in the firm's development decisions. Consider Boeing's development of the Sonic Cruiser, a supersonic jet that was designed by Boeing, but never made it off the drawing board. Boeing continued designing the aircraft even after it became clear that the jet would not be profitable because Boeing considered the project necessary for preserving the company's development capabilities.

FIGURE 7.5
The Project Map

Source: Steven C. Wheelwright and Kim B. Clark from *Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency, and Quality*.



As noted by Walt Gillette, Boeing's development program manager, "If the company doesn't create a new airplane every 12 to 15 years, the needed skills and experience will be gone. Too many of the people who created the last new airplane will have retired or moved on to other companies, and their skills and experience will not have been passed on to the next generation of Boeing employees."[14] Thus, Boeing's development of the Sonic Cruiser is expected to be valuable to the firm even if the only return from the project is the enhancement of the firm's development capabilities. Such value would be difficult to assess via quantitative methods, but is revealed clearly by qualitative analysis.

The Aggregate Project Planning Framework

Many companies find it valuable to map their R&D portfolio according to levels of risk, resource commitment, and timing of cash flows. Managers can use this map to compare their desired balance of projects with their actual balance of projects.[15] It can also help them to identify capacity constraints and better allocate resources.[16] Companies may use a project map (similar to that depicted in Figure 7.5) to aid this process. Four types of development projects commonly appear on this map—advanced R&D, breakthrough, platform, and derivative projects. Over time, a particular technology may migrate through these different types of projects. Advanced R&D projects are the precursor to commercial development projects and are necessary to develop cutting-edge strategic technologies. Breakthrough projects involve development of products that incorporate revolutionary new product and process technologies. For example, while Honda's work on hydrogen fuel cells might be considered an advanced R&D project since it is still a significant distance from a commercial application, the company's development of its original hybrid-electric vehicle, the Insight, would be considered a breakthrough project. The Honda Insight incorporated revolutionary new technology in a commercialized application.

Platform projects typically offer fundamental improvements in the cost, quality, and performance of a technology over preceding generations. Derivative projects involve incremental changes in products and/or processes. A platform project is designed to serve a core group of consumers, whereas derivative projects represent modifications of the basic platform design to appeal to different niches within that core group. For example, Hunter's Care Free humidifier is a platform that offers several derivative versions to appeal to different customer segments. The water storage tank comes in different sizes (e.g., 2.0 gallon, 2.5 gallon, 3.0 gallon); some models include a digital humidistat; and some also include Nite Glo lights. However, all of the models are based on the same Permawick filter design and fan system. Similarly, Toyota's Camry is a platform for a family of car models that includes the Camry LE, Camry SE, and Camry XLE. While all the models are based on the same basic design, each offers a different combination of features to appeal to different market segments. These variations on the Camry theme are derivative products.

Companies that use the project map categorize all their existing projects and projects under consideration by the resources they require (e.g., engineers, time, capital, etc.) and by how they contribute to the company's product line. The company can then map the project types and identify gaps in the development strategy.[17] Managers can also use the map to identify their desired mix of projects, and allocate resources accordingly. The mix of projects represented on such a map should be consistent both with the company's resources, strategic position, and with its strategic intent (as analyzed in Chapter Six). For example, a typical firm experiencing moderate growth might allocate 10 percent of its R&D budget to breakthrough innovation, 30 percent to platform projects, and 60 percent to derivative projects. A firm pursuing more significant growth might allocate higher percentages to breakthrough and platform projects, while a firm that needs to generate more short-term profit might allocate a higher percentage to derivative projects.[18] Respondents to a recent survey administered by the Product Development and Management Association indicated that roughly 8 percent of their projects were breakthrough or advanced R&D projects, 17 percent were platform projects, and 75 percent were derivative projects.

Mapping the company's R&D portfolio encourages the firm to consider both short-term cash flow needs and long-term strategic momentum in its budgeting and planning. For instance, a firm that invests heavily in derivative projects that may be immediately commercialized with little risk may appear to have good returns on its R&D investment in the short run, but then be unable to compete when the market shifts to a newer technology. On the other hand, a firm that invests heavily in advanced R&D or breakthrough projects may be on the leading edge of technology, but run into cash flow problems from a lack of revenues generated from recently commercialized platform or derivative projects. As once noted by Jack Welch, former CEO of General Electric, "You can't grow long term if you can't eat short term. Anyone can manage short. Anyone can manage long. Balancing those two things is what management is."[19]

This is poignantly illustrated in the pharmaceutical industry, where high project failure rates, long product development cycles, and reliance on patent protection can cause a firm to suddenly find it has a devastating gap in its product pipeline. Studies indicate that developing a new drug takes an average of 12 years and can cost as much as $2 billion by the time a product makes it through clinical trials. In 2017, many of the world's largest pharmaceutical companies were facing a "patent cliff" as the patents were expiring on many of their blockbuster drugs, exposing the firms to much heavier competition from generics. Furthermore, traditional pharma companies were beginning to be exposed to more competition from "biologics," treatments developed by biotech firms. This situation creates intense volatility in the revenues of a firm, which creates enormous pressures on the firm (including managing staffing, manufacturing capacity, managing R&D funds, and more). As a result, many pharmaceutical firms have begun shifting their emphasis to lower volume, specialty drugs that could potentially be more profitable because they would require less marketing investment and face less competition.

Q-Sort

Q-sort is a simple method for ranking objects or ideas on a number of different dimensions. The Q-sort method has been used for purposes as diverse as identifying personality disorders to establishing scales of customer preferences. Individuals in a group are each given a stack of cards with an object or idea on each card. In the case of new product development, each card could identify a potential project. Then a series of project selection criteria are presented (e.g., technical feasibility, market impact, fit with strategic intent), and for each criterion, the individuals sort their cards in rank order (e.g., best fit with strategic intent) or in categories (e.g., technically feasible versus infeasible) according to that criterion. Individuals then compare their rank orderings and use these comparisons to structure a debate about the projects. After several rounds of sorting and debating, the group is expected to arrive at a consensus about the best projects.[20]

COMBINING QUANTITATIVE AND QUALITATIVE INFORMATION

As demonstrated above, both quantitative methods and qualitative methods offer a number of benefits to managers in choosing development projects. Thus, many firms use a combination of methods to arrive at an investment decision.[21] For example, a firm might have screening questions that require quantitative analysis in addition to qualitative responses. Firms might also use quantitative methods to estimate the cash flows anticipated from a project when balancing their R&D portfolio on a project map. There are also valuation techniques that attempt to translate qualitative assessments into quantitative measures, such as conjoint analysis and data envelopment analysis, as discussed below.

Conjoint Analysis

conjoint analysis
A family of techniques that enables assessment of the weight individuals put on different attributes of a choice.

Conjoint analysis is a family of techniques (including discrete choice, choice modeling, hierarchical choice, trade-off matrices, and pairwise comparisons) used to estimate the specific value individuals place on some attribute of a choice, such as the relative value of features of a product or the relative importance of different outcomes of a development project. While individuals may find it very difficult to accurately assess the weight they put on individual attributes of a decision, conjoint analysis enables these weights to be derived statistically. Conjoint analysis enables a subjective assessment of a complex decision to be decomposed into quantitative scores of the relative importance of different criteria.

The most common use of conjoint analysis is to assess the relative importance to customers of different product attributes—these values can then be used in development and pricing decisions. For example, potential customers might be given a series of cards describing different models of a camera with different features and prices. The individuals are then asked to rate each in terms of its desirability (e.g., on a scale

Theory in Action Courtyard by Marriott

In the mid-1980s, Marriott was facing a nearly saturated market for full-service, upscale hotels. Marriott's managers knew that the only way to sustain the company's 20 percent annual sales growth rate was to expand its product line. Marriott's management believed there was a market opportunity in the moderately priced ($35 to $60 a night) hotel category. The dominant chains in this category (e.g., Holiday Inn, Howard Johnson) tended to receive poor marks for customer satisfaction, and Marriott's managers believed that a chain that provided newer facilities and more consistent service would be enthusiastically received by customers. They also knew, however, that the company's most valuable resource was its well-established brand name, and they were reluctant to hastily affix the Marriott name to a scaled-down version of its hotels.

The company constructed a carefully structured plan for evaluating potential designs for a midprice hotel line. The company first conducted focus groups to identify different customer segments and the major factors that influenced their purchase decisions. The factors identified included external surroundings, room, food, lounge, services, leisure activities, and security. Within each major factor, there were several specific attributes that could take on multiple levels of product or service quality. For example, within the "services" factor, one of the attributes was "reservations," and the company had two levels: "call the hotel directly" or "call an 800 reservation number." A sample of hotel customers was selected to participate in a research group whereby each participant was given a fictional $35 with which to build his or her own hotel. Each participant was given seven cards (one card for each of the major factors identified above). On the card was listed each of the specific attributes and their possible levels, along with a price for each level. The participants would evaluate one card at a time, selecting the features they desired. If participants went over the $35 budget, they were required to eliminate some features or choose a less expensive level of service. This technique helped management understand customer priorities and the trade-offs made by different customer segments. On the basis of these priorities, the managers then developed a series of hotel profiles offering different combinations of features and levels of service. Participants were then asked to rate each of these profiles. The managers could then use regression to assess how different levels of service within a specific attribute influenced customer ratings of the hotel overall. For example, as illustrated in Figure 7.6, after the hotel profiles are rated by the participants, the values for the levels in the profiles and the participant ratings can be entered into a spreadsheet. The ratings can then be regressed on the attribute levels, yielding a model that estimates the relative importance of each attribute.

On the basis of their conjoint analysis, Marriott's managers came up with the Courtyard concept: relatively small hotels (about 150 rooms) with limited amenities, small restaurants, small meeting rooms, enclosed courtyards, high-security features, well-landscaped exteriors, and significantly lower room rates than its traditional Marriott hotels. Courtyard by Marriott turned out to be very successful. By the end of 2017, there were 1145 Courtyard hotels (508 of those were in the United States), and their average occupancy rate of more than 70 percent was well above the industry average.

continued

of 1 to 10) or asked to order the models in terms of which they would most likely buy. Multiple regression is then used to assess the degree to which each attribute influences the overall rating, resulting in the assignment of specific weights to individual criteria. These weights provide a quantitative assessment of the trade-offs that customers implicitly consider in their evaluation of products. The firm can then use these weights in a series of "what if" scenarios to consider the implications of different product configurations. For example, Marriott used conjoint analysis to determine what features customers would most value in a moderately priced hotel. This analysis enabled Marriott to develop its very successful line of Courtyard by Marriott hotels (see the accompanying Theory in Action).

concluded

FIGURE 7.6
Hotel Profiles and Ratings for Conjoint Analysis

Hotel Profile 1	Hotel Profile 2	Hotel Profile 3	. . .
Reservations			
1–800 number (1)	Call hotel directly (0)	1–800 number (1)	
Room Service			
Full-menu, 24 hours a day (5)	Limited menu, offered 6 A.M. to midnight (3)	No room service (1)	
Newspaper Delivery			
None (0)	Daily (1)	None (0)	
(others)			

Attributes	Reservations	Room Service	Newspaper Delivery	(others)	Overall Rating (1–10)
Participant 1					
Hotel Profile 1	1	5	0		8
Hotel Profile 2	0	3	1		7
Hotel Profile 3	1	1	0		5
Participant 2					
Hotel Profile 1	1	5	0		7
Hotel Profile 2	0	3	1		9
Hotel Profile 3	1	1	0		4
(others)					

Source: Adapted from R. J. Thomas, New Product Success Stories (New York: John Wiley & Sons, 1995).

Data Envelopment Analysis

data envelopment analysis (DEA)
A method of ranking projects based on multiple decision criteria by comparing them to a hypothetical efficiency frontier.

Data envelopment analysis (DEA) is a method of assessing a potential project (or other decision) using multiple criteria that may have different kinds of measurement units.[22] For instance, for a particular set of potential projects, a firm might have cash flow estimates, a ranking of the project's fit with existing competencies, a ranking of the project's potential for building desired future competencies, a score for its technical feasibility, and a score for its customer desirability. Each of these measures captures something that is qualitatively different, and the numbers assigned to them are based on different units of measure. While the first measure is in dollars and is a nearly continuous measure, the second two measures are rank orders and thus are categorical measures with little information about what the difference is between one level of rank and another. The last two measures are scores that might be based on a ranking system or scaling system (e.g., a Likert measure that goes from one to seven).

FIGURE 7.7
DEA Ranking of the Advanced Technologies Group's 10 Most Attractive Projects and Every 50th Project Thereafter

Source: Adapted from J. D. Linton, S. T. Walsch, and J. Morabito, "Analysis, Ranking and Selection of R&D Projects in a Portfolio," *R&D Management* 32, no. 2 (2002), pp. 139–48.

Rank	Intellectual Property	Product Market	Investment	Cash Flow (most likely)	Cash Flow (optimistic)	Cash Flow (pessimistic)
1	2.25	1.5	$4322	$1,296,700	$1,353,924	$1,184,192
2	1.5	1.5	850	525,844	551,538	493,912
3	1.5	1.5	1	4	4	3
4	2.25	2.25	478	545,594	822,164	411,082
5	1.5	1.5	1	15	15	11
6	1.5	2.25	65	89,144	178,289	0
7	1.5	1.5	1068	685,116	1,027,386	342,558
8	1.5	1.5	4	3766	4707	2824
9	1.5	1.5	20	4800	4800	−96
10	1.5	2.25	2	23	27	18
50	1.5	2.25	9	116	139	93
100	1.5	1.5	15	60	72	48
150	2.25	2.25	40	5531	13,829	2766
200	2.25	1.5	38	90	135	45

efficiency frontier
The range of hypothetical configurations that optimize a combination of features.

Data envelopment analysis uses linear programming to combine these different measures from the projects to create a hypothetical **efficiency frontier** that represents the best performance on each measure. It can also consider which measures are inputs (such as costs) versus outputs (expected benefits). It then measures the distance of each project from this frontier to give it an efficiency value. These values can then be used to rank-order the projects or identify projects that clearly dominate others.[23] For example, Figure 7.7 shows a DEA ranking of projects evaluated by the Advanced Technologies Group of Bell Laboratories. The Advanced Technologies Group chose to evaluate projects in terms of three measures of discounted cash flows expected from the project (most likely, optimistic scenario, pessimistic scenario), the investment required, and each project's desirability from the perspective of intellectual property benefits and product market benefits. For the latter two measures, projects were given a score of 1, 1.5, or 2.25 based on the group's model for intellectual property and product market benefits. These scores reflect this particular group's scoring system—it would be just as appropriate to use a scaled measure (e.g., 1 = very strong intellectual property benefits, to 7 = no intellectual property benefits), or other type of measure used by the firm. As shown, the DEA method enabled Bell Laboratories to rank-order different projects, despite the fact that they offered different kinds of benefits and risks.

The biggest advantage of DEA is that it enables comparisons of projects using multiple kinds of measures. However, just as with several of the methods described previously, the results of DEA are only as good as the data utilized. Managers bear the responsibility of determining which measures are most important to include and of ensuring that the measures are accurate.

Summary of Chapter

1. Firms often use a combination of quantitative and qualitative methods to evaluate which projects should be funded. Though some methods assume that all valuable projects will be funded, resources are typically constrained and firms must use capital rationing.
2. The most commonly used quantitative methods of evaluating projects are discounted cash flow methods such as net present value (NPV) or internal rate of return (IRR). While both methods enable the firm to create concrete estimates of returns of a project and account for the time value of money, the results are only as good as the cash flow estimates used in the analysis (which are often unreliable). Both methods also tend to heavily discount long-term or risky projects and can undervalue projects that have strategic implications that are not well reflected by cash flow estimates.
3. Some firms now use a real options approach to assess projects. Real options better account for the long-run strategic implications of a project. Unfortunately, many new product development investment decisions do not conform to the assumptions inherent in an options valuation approach.
4. One commonly used qualitative method of assessing development projects is to subject the project to a series of screening questions that consider the project from multiple angles. These questions may be used merely to structure the discussion of a project or to create rating scales that are then utilized in an approach that combines qualitative and quantitative assessment.
5. A company's portfolio of projects typically includes projects of different types (e.g., advanced R&D, breakthrough, platform, and derivative projects) that have different resource requirements and different rates of return. Companies can use a project map to assess what their balance of projects is (or should be) and allocate resources accordingly.
6. Q-sort is a qualitative method of assessing projects whereby individuals rank each project under consideration according to a series of criteria. Q-sort is most commonly used to provide a format for discussion and debate.
7. Conjoint analysis is a method of converting qualitative assessments of a choice into quantitative weights of the different criteria underlying the choice. It is most often used for assessing how customers value different product attributes.
8. Data envelopment analysis (DEA) is another method that combines qualitative and quantitative measures. DEA enables projects that have multiple criteria in different measurement units to be ranked by comparing them to a hypothetical efficiency frontier.

Discussion Questions

1. What are the advantages and disadvantages of discounted cash flow methods such as NPV and IRR?
2. For what kind of development projects might a real options approach be appropriate? For what kind of projects would it be inappropriate?
3. Why might a firm use both qualitative and quantitative assessments of a project?

4. Identify a development project you are familiar with. What methods do you believe were used to assess the project? What methods do you believe *should have been* used to assess the project?
5. Will different methods of evaluating a project typically yield the same conclusions about whether to fund its development? Why or why not?

Suggested Further Reading

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