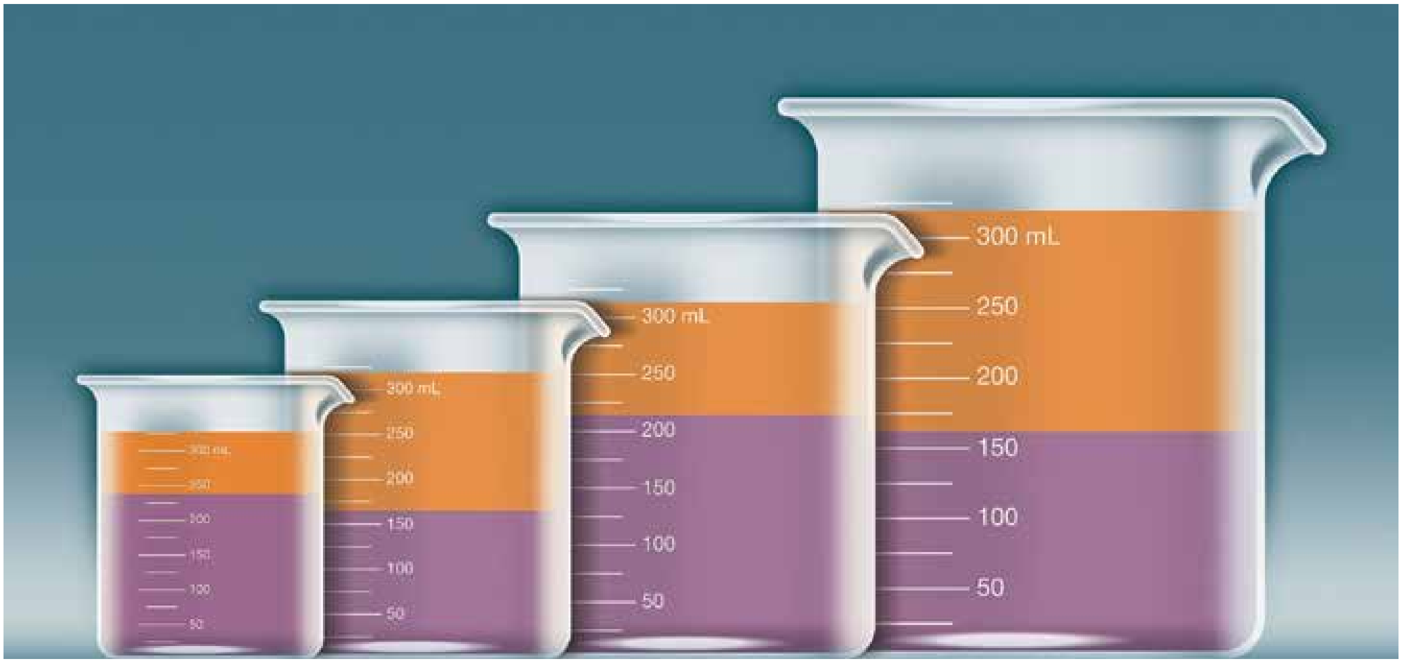
McKinsey on Chemicals



Chemical innovation: An investment for the ages

Innovation still clearly pays off. Smart innovation-portfolio design and better market insight can make it pay even better.

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Innovation has long been considered a cornerstone of growth and profitability for chemical companies and a prerequisite for long-term performance. However, commoditization of parts of the industry has weakened some companies' and investors' faith in innovation, and many often fail to see the clear link between R&D spending and eventual returns. This article takes a new look at innovation data to show that while most chemical innovation continues to be solidly rewarding, with returns well above the cost of capital, there are major variations in the outcomes of innovation projects. It also shows that a carefully defined innovation-portfolio strategy and improved market-insight capability can alleviate many of the concerns about returns held by companies and investors.

A new cut on innovation returns

It is well recognized that there is a high degree of variability in innovation performance, and companies have thought hard about the drivers of success. The drivers that have been considered touch on strategy ("Which megatrend is for us?"), finance (“Should we spend more?”), organization (“How have we structured our R&D?”), and capabilities, including the degree of technology and market knowledge the company deploys.

We believe some particularly helpful insights emerge when looking at innovation performance with respect to these capabilities. In recognition of this, we created a simple matrix to classify innovation according to the degree of market familiarity and the degree of technical familiarity that the launching company had at the time of a product’s launch (Exhibit 1).

We used this framework to categorize projects, considering the three factors that are the principal components of chemical companies’ innovation performance: the length of time it takes to commercialize a product, success rates across an innovation portfolio, and the financial returns of new products.

We gathered information on innovation in chemicals from three main sources:

- *Analysis of major chemical-product launches.* We selected 35 chemical innovations that are well established in the market, have substantial sales, and are assessed as profitable by their manufacturers. We then interviewed more than 50 industry participants and reviewed trade literature on these chemicals to determine their time to commercialization. No company-proprietary data were used in developing this data set.

- *Interviews with R&D leaders.* We interviewed 20 R&D leaders from ten major US chemical companies regarding their companies’ experience with investing in innovation, in association with the Council for Chemical Research. The companies cover a breadth of commodity and specialty products and are at the forefront of

Exhibit 1

A matrix helps companies classify innovations.

the industry's work on innovation. We explored with these individuals three aspects of innovation investment: time to market, expectations for internal rate of return (IRR),[1] and failure rates of chemical-innovation projects.

- *Meta-analysis of McKinsey's Innomatics database.* We analyzed data[2] from 118 chemical-company business units with sales greater than $2 billion per year to determine the IRR on their innovation projects. (See the sidebar for more information on the Innomatics database.)

While we recognize that the approach and methodologies used here inevitably have limitations, we believe that they provide a reasonably accurate and broad understanding of the chemical-innovation landscape and returns on innovation in chemicals.

Time-to-commercialization and success rate

As noted earlier, time to commercialization and success rate are two of the three critical components of innovation success. For the purposes of this article, we have defined time to commercialization as the elapsed time between formal project initiation and the point at which the project's annual sales equal the total R&D investment in it. We have defined the success rate as the portion of projects in a given quadrant that created a positive return on a net-present-value (NPV) basis, using the innovator's cost of capital (with no risk adjustment). We determined time to commercialization using the data on the 35 products and the insights gained in the interviews with the R&D leaders; we determined success rates based on our interviews.

[1] The internal rate of return is the cost of capital at which the net present value equals 0 percent.

[2] Data were collected between 2006 and 2010.

Exhibit 2

The time required for commercialization can vary substantially.

Degree of market familiarity	Degree of technology familiarity: High	Degree of technology familiarity: Low
Low	**Product-line extensions into new markets** Success rate: 30–40% Time to commercialization: 2–7 years (average 5)	**New-product launches in new markets** Success rate: 15–20% Time to commercialization: 8–19 years (average 14)
High	**Product-line extensions into existing markets** Success rate: 40–50% Time to commercialization: 2–5 years (average 4)	**New-product launches in existing markets** Success rate: 30–40% Time to commercialization: 6–15 years (average 11)

Our findings across the four quadrants show meaningful variations in success rates among the categories and substantial differences in the time required for commercialization, from a minimum of 2 years to as long as 19 years (Exhibit 2). The time to commercialization was fairly equally divided between the R&D phase (that is, from project initiation to product launch) and the market-introduction phase (that is, from product launch to reaching annual sales equal to total R&D investment), although again with substantial variation among products. It is also important to note that the success rates shown in the exhibit represent typical values; we recognize that there are outlier companies that have registered higher and lower scores in each quadrant.

We can examine time to commercialization and success rate by quadrant:

- *High market familiarity, high technology familiarity.* Knowledge of the market and the technology translates to quick time to commercialization (two to five years) and a high success rate (40 to 50 percent). This is a comfortable space to work in for companies' R&D and commercialization teams. Products in this quadrant are typically extensions of existing products intended to meet the needs of a well-known market, and costs of development tend to be relatively low.

- *Low market familiarity, high technology familiarity.* Low market familiarity increases the time to commercialization (to two to seven years) and typically results in a lower success rate (30 to 40 percent). These types of projects often are relatively small from a technical standpoint and simply port a technology from one market to an adjacent one with minimal modifications.

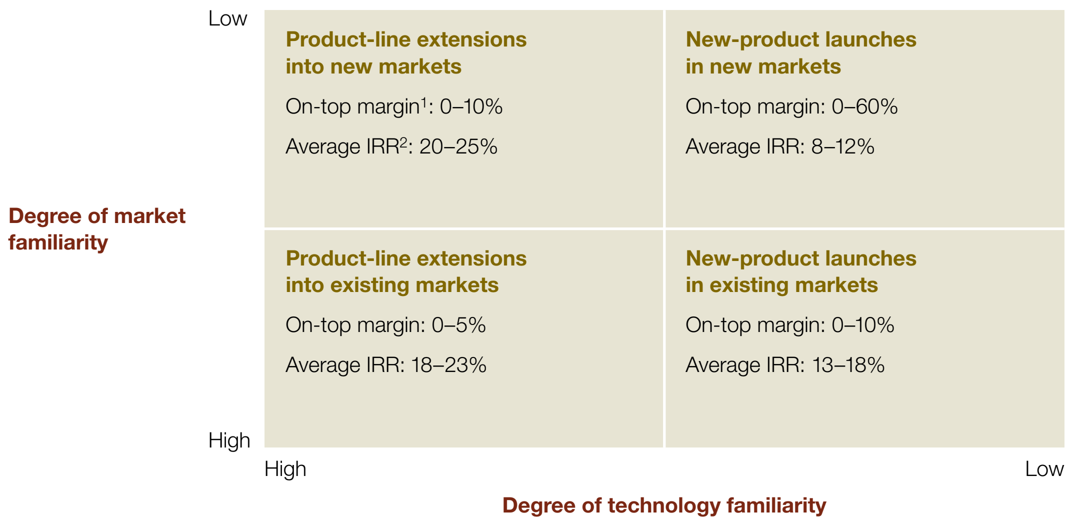
  That said, understanding new markets—even adjacent ones—is notoriously difficult for chemical companies. Entering a new market almost always takes longer than expected and also drives down success rates.

- *High market familiarity, low technology familiarity.* Low familiarity with technology significantly increases time to commercialization (to 6 to 15 years). The technology investment in projects of this type is relatively high. Interestingly, a sizable portion of this investment is used for testing and qualification, as companies tend to be quite careful to protect their reputations in existing markets. The success rate here is similar to that of the quadrant with low market familiarity and high technology familiarity, at 30 to 40 percent, mainly due to the high risk inherent in developing new technologies.

- *Low market familiarity, low technology familiarity.* This type of innovation presents the highest level of risk. We see the highest time to commercialization (8 to 19 years) and the lowest success rate (15 to 20 percent) here. Companies face the difficult tasks of both identifying and understanding new markets and developing new technologies that are not extensions of current ones. It appears that the majority of time in this category is driven by technology development, while the key driver of the low success rate is failure to understand the needs of the market—essentially launching an elegant technology that misses the mark from a commercial standpoint. In our experience, the most pervasive root cause of this "market mismatch" is lack of context: chemical companies tend to act on signals in new markets that are similar to those they hear in existing markets. However, without a proper understanding of market context, they launch products that

Exhibit 3

The highest margins come with the highest risk.



[1] On-top margin is defined as the differential between the internal rate of return (IRR) of a new product based on innovation and the IRR of an incumbent product in the market that it replaces, net of cannibalization.
[2] Internal rate of return.

perfectly meet the needs they heard but fail to meet all of customers' other needs.

How technology and market familiarity affect financial returns

The rate of return on an innovation-investment project also varies given the company's level of familiarity with the market and the technology. Because we examined the 35 chemical innovations using externally available data, we were unable to estimate their total financial impact. However, we were able to assess the financial impact of innovation through our interviews with chemical executives. We probed two areas with them. First, we discussed their experience and expectations regarding IRR, including success rates, typical costs, and expected sales. Second, we explored the additional margin that innovations gained versus the products they replaced, net of cannibalization; we call this additional margin "on-top margin" (Exhibit 3). In our determination of IRR, we used the full return on the new project—without excluding cannibalized sales, as it can be assumed that without innovation, these sales would go to a competitor that innovates instead.

The highest on-top margins—and the highest variability in these margins—occur in the highest-risk category (that is, low familiarity with both market and technology). The lowest on-top margins are in the category with the highest familiarity with both the market and technology. Interestingly, a comparison of IRR returns for these two categories shows the reverse pattern, with the lowest risk earning the highest returns as measured by IRR. This is because IRR performance is driven to a significant degree by success rates and time to market. Again, it is important to note that the success rates represent typical values; we recognize that there are outlier companies in each quadrant.

We can observe the effects by quadrant:

- *High market familiarity, high technology familiarity.* Our research shows that on-top margins in this quadrant range between 0 and 5 percent, the lowest of all four categories. However, returns are high because development and capital investment are typically quite low, success rates are high, and volumes are generally substantial, leading to an average IRR in the range of about 18 to 23 percent. Often, these innovation investments are incremental in order to protect market share or tweak existing products to drive further value.

- *Low market familiarity, high technology familiarity.* Our interviewees indicated that this space can offer higher on-top margins (as much as 10 percent higher than incumbent products) than the previous category. This is possibly because entries here can bring truly novel properties that existing products lack. These investments usually offer high returns, in the range of 20 to 25 percent, because investments in both development and capital are typically quite low.

- *High market familiarity, low technology familiarity.* New technologies in existing markets often gain strong on-top margins (up to 10 percent higher than incumbent products), driven by a combination of novel properties and an understanding of market needs. However, given the new technology's higher capital requirements and typically longer time to market, the returns of such projects are often lower than those in the first two categories, in the range of about 13 to 18 percent.

- *Low market familiarity, low technology familiarity.* This type of innovation presents the highest level of risk but has the highest on-top margin potential (up to 60 percent). The low success rates and long time frames in this space lead to typical returns on investment in the range of only 8 to 12 percent, which barely covers the cost of capital for most chemical companies (usually 9 to 12 percent). Indeed, some executives we interviewed expressed skepticism that these investments would be NPV positive at all.

Moving beyond the matrix framework, we compared the ranges of IRR compiled there with the Innomatics database and found that both data sets showed a similar range of returns. Our meta-analysis of the Innomatics database by market segment (commodity, specialty, materials, and nonpharma life science) points to a strong average return—14 to 18 percent IRR—for innovation by chemical companies (Exhibit 4).

Innomatics is a proprietary McKinsey innovation database and tool that covers approximately 130 business units of leading chemical companies. Designed as an innovation-benchmarking tool, Innomatics makes it possible to compare the R&D performance of different business units, creating a perspective on a business unit's return on investment in chemical innovation. The inputs into the tool include time to market, product life cycle, innovation capital expenditure, and innovation profit and cash flow. The key output is an assessment of innovation performance, based on internal rate of return, for each business unit and company, which can be readily compared with other chemical companies in the database.

Exhibit 4

The average return for innovation is strong.

Breaking down the sample

IRR[1] for new chemical products, %		Revenue, $ billion	R&D spending, $ billion	Business units, Number
Materials	19–23	2.4	0.3	21
Nonpharma life science	15–19	3.2	0.7	28
Specialties	13–17	6.4	1.0	54
Commodities	6–10	0.6	0.1	15
	14–18	**12.6**	**2.1**	**118**

[1] Internal rate of return.
Source: McKinsey Innomatics database

In addition, the Innomatics database provides further insight: it shows that market segment has a large effect on financial performance. Commodities segments yield only 6 to 10 percent IRR (at or below the cost of capital), while returns in other segments are significantly higher. Material-science innovation takes the top position at 19 to 23 percent.

Spending allocation

In our interviews, we also examined the allocation of R&D spending within companies' portfolio of products. Most of our interviewees indicated that their companies spend 40 to 50 percent of their R&D investment on projects in which they are familiar with both the market and the technology.

This high allocation has made sense to chemical companies because innovation in this case is typically incremental and returns are apparently safest, as extensions of existing products are meant to better capture markets that the company is already familiar with. The remaining R&D spending is usually divided roughly equally among the other three categories, with 15 to 20 percent of total spending devoted to each of them.

How innovation scores

The work presented in this article clearly shows that investment in innovation is, by and large, a value-creating activity for chemical companies, a finding that confirms many earlier studies. It creates value well above the cost of capital in all but one of the quadrants of our matrix, and returns in the low-return quadrant (low market familiarity, low technology familiarity) are still around 10 percent.

It should not be overlooked that our methodology (which uses purely financial metrics) likely understates the true value of innovation for most chemical companies. The methodology does not take into account the impact of innovation-based growth on corporate valuation or the contribution such growth makes from a strategic standpoint. It also does not include a view on how incremental innovation provides defensive value by helping a company to maintain share in core markets or by expanding into new markets as core markets deteriorate. Getting an accurate perspective on these factors would require a much deeper exploration, but we estimate that they could add 5 to 10 percent or more to the IRR of successful innovations and roughly 2 to 5 percent for the total pool.

Three ways to improve innovation performance

While it is good news that chemical innovation creates value in the aggregate, there is another important message that senior chemical-company management can take from this paper: returns from chemical innovation can clearly improve. Our analysis indicates that there are at least three areas where change can have a significant impact:

- *Modifying the innovation-portfolio balance.* The difference in return between projects in the quadrant with low market familiarity and low technology familiarity and projects that fall into the other categories is striking—a difference of two times. While it is clear that this new-market and new-technology area is far riskier than the others, the compounding effect that long development time frames have on that risk and consequently on IRR appears to be less understood in the chemical industry.

  Many companies argue that entry into this space is required to truly transform performance. While the idea is alluring, our experience has shown that entry into new technologies for a well-known market or into a new market with a well-known technology can have similar transformational effects—but with much less risk, a shorter time frame, and higher returns. Overweighting those two categories versus the new-market, new-technology area (without eliminating all new-new investment) in a company's innovation portfolio could significantly improve overall returns.

- *Elevating market-insight capabilities.* Most chemical companies are good at understanding the needs of existing customers in existing markets but are weaker at generating insights about new markets. In fact, an examination of the results in our matrix shows that the failure rate for innovations in the new-market, familiar-technology space is similar to that of the familiar-market, new-technology space. Thus, the risks of market entry are similar to those of developing a new technology.

  Nonetheless, we have found the focus on market-insight capabilities at most chemical companies to be far lower than the focus on technology capabilities. While developing market insights is neither easy nor cheap, doing so is far quicker and less expensive than developing technology; investing in this area reduces risk, accelerates commercialization, and increases returns. Done well, market-insight capabilities are effectively a "force multiplier" for technology investment.

- *Improving innovation discipline.* Many innovations, especially those with new technology, require the deployment of new capital during commercialization. Performed incorrectly, this additional capital requirement can easily destroy innovation returns. Far too many companies take the view that new products must be launched from full-scale plants in order to meet cost targets and qualification requirements. We have shown in previous work[3] that this view is mistaken: chemical and material innovations are most often adopted at a higher cost than incumbent products. Instead of deploying very large amounts of capital to build world-scale plants, companies should almost always take a measured approach with flexible pilot plants that allow for modification of properties to meet market needs. This approach reduces overall risk in two ways: it lowers the total capital outlay and increases the probability of adoption.

More broadly, this article speaks to the importance of innovation discipline and finding the right model for innovation and commercialization, the lack of which diminishes the likelihood of success. Adopting a clear and disciplined approach to innovation that is specified based on the kind of dynamics and technology of the target market is typically associated with better success rates and returns. Examples of these target-market-specific models include the start-up or venture-capital approach to innovation, which provides clear guidelines on risk-and-return trade-offs; a platform approach that unifies a group of new technologies based on end-market needs and dynamics; and real-options-based approaches that allow companies to "buy up or down" depending on the performance of a project at a given stage.

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Given the pace of technological change in downstream industries that rely on chemicals to enable their advances, it is critical that chemical companies continue to innovate. The approaches outlined in this article can help increase the efficiency and effectiveness of innovation and improve returns. They cannot, however, guarantee that the chemical industry can continue to support the pace of progress in key industries such as electronics and energy. Doing that will require concerted efforts from visionary chemical-industry leaders, close partnerships with downstream chemical users, and a policy environment that encourages investment and technology development.

[3] See Michael Boren, Vanessa Chan, and Christopher Musso, "The path to improved returns in materials commercialization," *McKinsey on Chemicals*, May 2012.

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