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The path to improved returns in materials commercialization

Six failure modes bedevil chemical companies when it comes to commercialization of new products and materials. Companies that deploy the right capabilities can dramatically speed up times to launch and to achieving meaningful revenues.

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Chemical and materials companies invest a significant portion of their capital in research and development: typically 2 to 3 percent of sales for commodity players and as much as 10 percent for some specialty companies. However, the long lag time for new materials to realize meaningful revenue is a major source of frustration among executives. In some cases, as many as 20 years can pass between the time a product is launched and the time it yields substantial revenue. Given this history, many investors and executives have lost faith in new chemical or materials product launches as viable near-term producers of revenue; product launches in other industries perform better in comparison (Exhibit 1).

This is one reason companies increasingly place their investments in line extensions or incremental product improvements. Launching new classes of chemicals and materials promises to open up entirely new markets, but investment is unappealing because the process is lengthy and involves much uncertainty.

Yet not all such launches are doomed to a slow ramp-up in revenue. While we have not found many companies that consistently launch new materials quickly and successfully, we have observed a number of successful launches. By comparing the successes and failures, we have identified important failure modes that companies encounter related to both value-proposition and market-segmentation issues, and the capabilities that companies can deploy to commercialize successfully. Understanding and avoiding these failure modes can reduce time to achieving appreciable revenue by as much as 50 percent.

Value-proposition-related failure modes

The value proposition of most materials is simply a performance or cost improvement over alternatives for a given set of market needs. Too often, market needs and the value proposition of new materials are misaligned, which invariably leads to disappointing market share and long adoption time. This misalignment comes in three flavors.

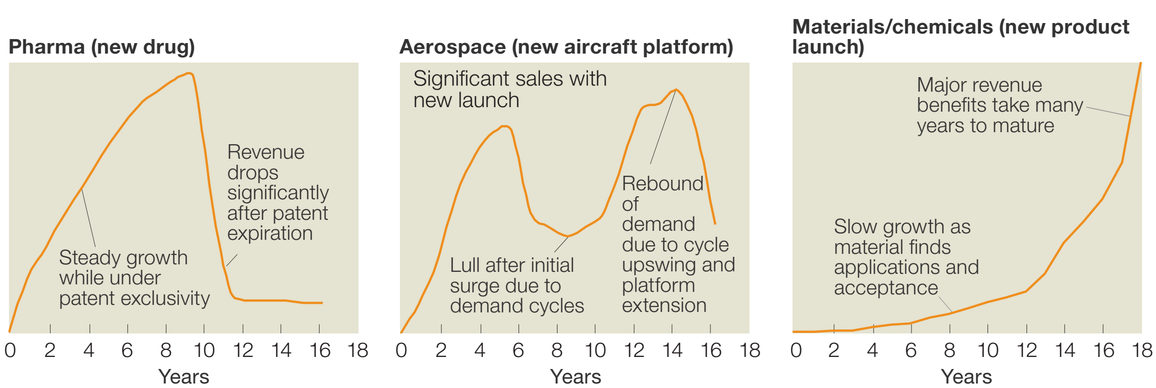
Failure mode 1: The risk disequilibrium

We hear all too often from materials innovators that their customers' testing cycles are irrationally long: "If they could only understand the benefits of our material, they would fast-track it." While it is true that most product manufacturers have waste and downtime in their test cycles, the main issue is that materials producers tend to fail to understand the risks that their materials create. While the benefits of a new material can be exciting, there is often a great disequilibrium between those benefits and the potential liabilities of failure. Consider, for example, the launch of a new lightweight structural material in the automotive space. The material could offer substantial, quantifiable benefits for critical objectives such as fuel efficiency, but if it failed, it would expose the vehicle manufacturer to tremendous warranty costs or safety issues. As a result, even for this critical need, original equipment manufacturers (OEMs) have instituted comprehensive, arduous—but very rational—testing loops that can last many years, severely damaging the business case for the new material.

There are some application segments that seem to systematically require extended testing because of the risk disequilibrium, but that nonetheless appear irresistible to materials innovators. Entering these spaces typically promises outsize profits and outstanding long-term positions as a specified material in a product, yet often results in broken hearts and canceled materials-

Exhibit 1

Revenue evolution to peak and beyond for various industries



development programs. We affectionately call them "impossible" entry segments and find it is rarely advisable to try using them as primary launch spaces. These segments include high-liability arenas such as automotive-safety equipment, in-the-body medical devices, and primary-aerostructure components.

The entry of carbon fiber (CF) into the primary-aerostructure market illustrates the problem. While benefits from the material's light weight and stiffness seem nearly perfectly suited to aircraft construction, there are obviously extreme consequences if primary aerostructures fail. While the core CF material technology was developed in the mid-1960s, it took more than 20 years to find appreciable use in commercial aerostructures and more than 30 years before it became the primary material for the Boeing 787's aerostructure, the first predominantly CF commercial aircraft. Luckily, producers found other uses for the material (including military and sporting-goods applications) while waiting for adoption to spread; otherwise, the world may never have enjoyed the benefits that CF composites bring.

Failure mode 2: Poor segmentation

Companies with exceptional new materials tend to believe that their products appeal to a much broader market than they actually do. This conviction can lead to a dramatic overestimation of market opportunities (often based on the belief that older products will be completely replaced by the new product); companies then overinvest in capacity and broad, fragmented sales and marketing efforts that bear little fruit. This is the result of poor segmentation in the initial strategic marketing. We have seen poor segmentation in many markets, including bioplastics ("We can attack—and win—in all packaging spaces"), construction products ("Our additives will be accepted in every type of concrete, regardless of application"), and electronics ("Why wouldn't every consumer want a more energy-efficient lightbulb enabled by our technology?"). In each of these cases, more detailed market-segmentation analysis revealed that the incumbent offered a superior value proposition for the majority of segments, though the new material surpassed the innovator's expectations in select spaces. Avoiding undersegmentation leads to more effective launch campaigns and better matching of capacity to likely demand, both of which dramatically improve the return on innovation investment.

Failure mode 3: The utopian illusion

Most new materials are developed based on a distinctive set of properties that is discovered during early research and development. Unfortunately, companies often become enamored with that set of properties and start to view the material as a utopian panacea, losing sight of how the material actually satisfies customers' needs. They begin to believe that the virtues of the distinctive properties will provide so much value to customers that the material's shortcomings will be overlooked. This is rarely true. More often, the material performs well on one or two requirements, but incumbents may have a stronger value proposition for the complete set of customer requirements. This results in either a lack of adoption or, worse, a flash-in-the-pan launch.

The early launch of high-density polyethylene (HDPE) in the United States is a prime example of companies falling prey to this utopian illusion. HDPE was originally promoted as a superior replacement to low-density polyethylene (LDPE)—capable of doing everything LDPE could do while providing higher heat resistance and greater

Benefits that a new material brings to end users do not always equate to benefits to value-chain players.

stiffness, which could open up new applications—and major new plant investments were made. HDPE producers aimed their product at the bottle market and targeted dish-detergent containers for their first conquest. To displace metal containers that held the market, producers highlighted HDPE's elimination of rust, dents, and leaks, as well as its moldability into attractively-shaped containers—and successfully presold their plant output on these claims.

Early adopters found, however, that not only was HDPE hard to mold (a drawback known from early tests but overlooked in the rush to market) but also that the new bottles suffered stress fractures. The result: a mass customer exodus and warehouses full of unsold resin. Two years of further development finally enabled HDPE to penetrate the detergent bottle market—one that it has dominated ever since. While the HDPE example dates from 50 years ago and ultimately has a happy ending, launch flops in the intervening years show that the utopian illusion has continued to cast a powerful spell over companies, with a roll call of examples in biopolymers, engineering plastics, elastomers, and electronic materials.

Value-chain-related failure modes

Our research shows that value-chain obstacles can have a tremendous effect on the adoption time for new materials. We have identified three value-chain-related failure modes.

Failure mode 4: Stifled by the loser

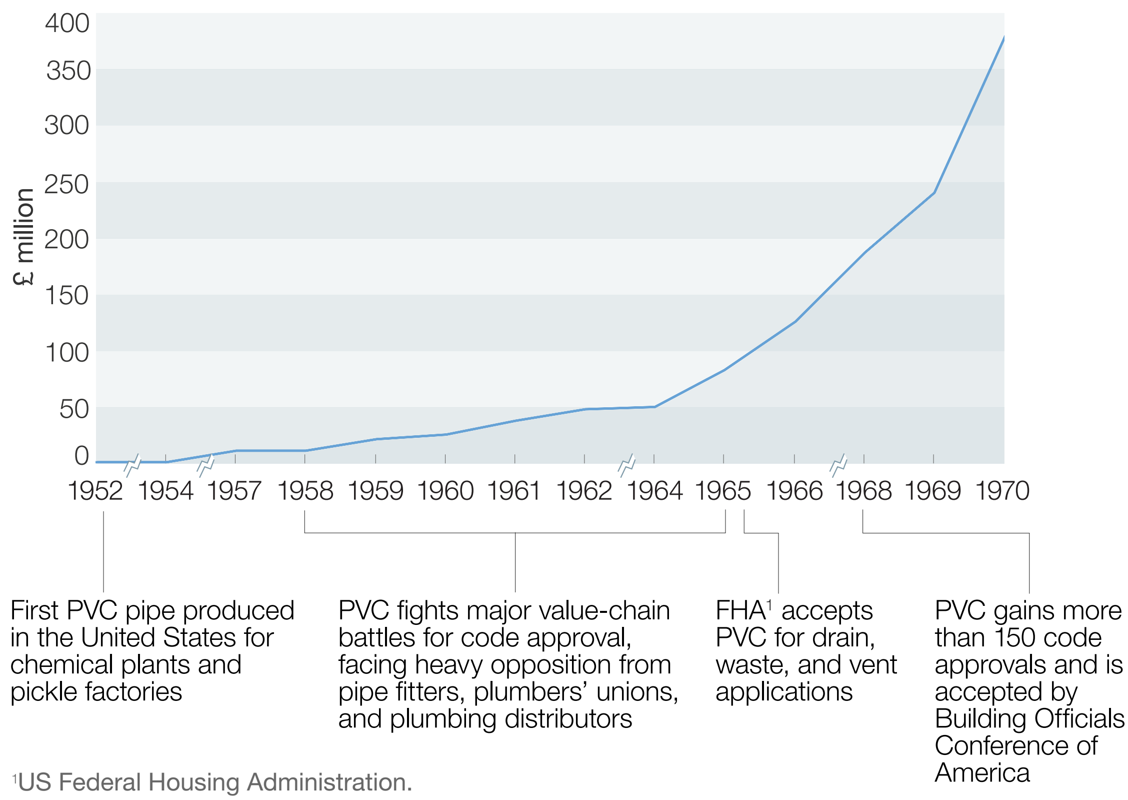
New materials are typically matched to markets because of an outstanding performance characteristic that will benefit the end user. However, benefits to the end user do not always equate to benefits to value-chain players. Value chains are often built up—intentionally or inadvertently—to maintain the status quo, generally in the name of quality and on-time delivery. When a new material threatens to negatively affect the status quo, there will naturally be resistance to its adoption. Perhaps the best historical example of this is the adoption of polyvinyl chloride (PVC) pipe in the United States. Although PVC pipe has grown to be one of the biggest plastics applications, it did not reach reasonable volume until nearly 15 years after its launch. PVC pipe was introduced in North America (as corrosion-resistant pipe for pickle factories) in about 1952, yet widespread use in the all-important housing market did not occur until at least 1965.

Although PVC was less expensive than other options and adequately durable, penetration was slow because it created two losers in the plumbing value chain: plumbers and pipe distributors. PVC threatened plumbers because it simplified a major portion of their hourly work and distributors because it was much less profitable than incumbent metal options. These groups fought hard to keep it out, resulting in approvals delays, which were not fully resolved until 1968—several years after PVC was ready for market (Exhibit 2).

Exhibit 2

PVC pipe sales took nearly 15 years to reach reasonable volume.

Polyvinyl chloride (PVC) pipe sales



[1]US Federal Housing Administration.
Source: Modern Plastics; McKinsey analysis

Failure mode 5: 'Drop-in' solution

As seductive as the concept is, and as often as the promise is made, we are skeptical that the elusive "drop-in replacement" material actually exists, and we have found its pursuit considerably extends time to market. Although there are materials that require limited changes at individual steps of the value chain, commercializers must consider the whole chain when launching new products in order to avoid barriers. There have been numerous initiatives, for example, to use plastics as drop-in replacements for metals and other polymer-based materials in markets such as automobile body parts. Unfortunately, in a significant number of cases the new materials have run into thermal- and chemical-stability issues, developing stress cracks and being unable to perform across the required range of environmental conditions. In the case of automobile assembly, there have also been compatibility issues in key steps such as coatings. Materials producers therefore need to carefully assess their product's performance along the complete value chain, or risk unexpected delays in uptake.

Failure mode 6: Complex value chain

Our research and experience have shown that value-chain complexity has a significant influence on adoption time. Value-chain complexity comes from many sources, including the number of steps in the chain, geographical spread, and contract structures. Complex value chains can inhibit adoption simply because they require such substantial realignment to accommodate new materials. From our perspective, the evergreen promise of polycarbonate (PC) automotive glazing has so far succumbed to value-chain complexity. Although PC glazing can offer dramatic weight-reduction benefits, it has taken far longer than expected to gain scale. Adoption of PC glazing requires multiple supplier tiers to change their production processes, which they are unwilling to do unless they have a clear promise that OEMs will buy the new material. OEMs, however, are unwilling to buy the new material until they see a stable supply chain. As such, materials often face a catch-22, where each player in the value stream is waiting for the others to make the first move. Furthermore, the risk of failure associated with adoption—which causes players in the value chain to raise their prices—increases as the chain becomes more complex, often erasing the original value proposition of a new material.

Improving commercialization through strategic segmentation and market selection

Leaders of the most successful commercialization projects approach the challenge differently than others do. They dig much deeper—and at a much earlier stage—into the value proposition of their products (an activity we call "strategic segmentation"), and they are very selective in choosing entry markets.

Strategic segmentation is a structured process in which technical experts and strategic marketers cooperate to identify the most likely markets—and then market segments—for a new material. While most companies believe they do this, most fail to do so with the necessary rigor. Our experience is that a successful strategic segmentation requires effort and rigor similar to that expended by a mergers-and-acquisitions team doing due diligence on a target.

The process begins with a broad scan of potential applications, based not only on the obviously attractive material properties but also on unique property combinations and more obscure traits. The company then tests the fundamentals of each target market (size, profitability, growth, and critical tailwinds that will help or hurt the need for new materials) and identifies the most exciting segments. The segmentation team tests the basic hypotheses of the value proposition in the most attractive segments, with the dual goals (by segment) of quantifying the value in use versus incumbents and identifying the drawbacks of the new material. This is typically done over the course of one to two months and involves critical analysis of materials properties, dozens of interviews with end users and converters, and often some prototyping to demonstrate the value proposition.

The result of strategic segmentation is a set of target segments in which the material can potentially play, as well as a much different—stronger or weaker—corporate conviction about the true market potential for the material. This conviction leads to appropriate scaling of both ambition and resource investments.

Strategic segmentation is also critical to dealing with value-chain failure modes, because it informs the most important decision related to commercialization timing: the selection of entry applications. Materials are unique in that they can often be used in many different applications but have one property that can dramatically improve their commercialization potential. The best commercializers take advantage of this property by seeking applications with the best balance of a strong value proposition and low value-chain barriers, recognizing that the two are quite different: that is, the application with the strongest value proposition may not be the best overall creator of value if it will take a long time for adoption to spread. The shortest possible value chain in which players have similar incentives for adoption will be the quickest.

Additionally, the best commercializers are willing to create novel business models to sidestep or eliminate value-chain barriers. There are many ways to do this: value-chain partnerships can be forged to create impetus for value-chain players to adopt materials; switching-cost

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Exhibit 3

Commercialization diligence can dramatically improve the value potential of a new material.

Understand true value proposition of material by segment	Map value chain and key influencers	Develop launch strategy and growth curve	**Typical impact:** acceleration of volume by 12 or more months

Phases of commercialization diligence

Understand true value proposition of material by segment

- What are the unique material properties?
- What are the material drawbacks?
- How is the material different from others?
- Which customers care about material properties?
- How much value will the material create in key segments?
- How much will customers pay?
- How big are potential markets?

Map value chain and key influencers

- What are the key value chains?
- What has to change for the material to work?
- Who loses if the new material wins, and how will they react?
- Who are value-chain gatekeepers?
- Who influences gatekeepers?

Develop launch strategy and growth curve

- How is the material likely to grow?
- How should attacks on markets and geographies be sequenced?
- What is the business model that maximizes value and minimizes delay?
- What major risks does the material face?

Key outputs

- Understanding of the value proposition in key segments, which may differ from the initial hypothesis
- Clear picture of the value chain, barriers, and influencers
- Initial commercialization strategy/direction
- Growth curve for new material

subsidies can be offered to offset required investments in process, technology, or logistics for value-chain players; the commercializer can mimic incumbents by modifying properties to closely match existing products in order to simplify adoption; or the commercializer can pursue forward integration, owning (by acquiring or building) all of the value-chain steps that could limit adoption. The last approach was used to drive the adoption of PET[1] bottles, and it is being widely employed today in the development of CF composites for automobiles by companies such as SGL.

Building institutional commercialization muscle

Building commercialization muscle is not easy, but it can be done. A sequential commercialization-diligence process can be effective to begin institutionalizing this capability (Exhibit 3). However, experience has shown that a process alone is insufficient in the chemical and materials industries. Because most marketers and researchers in those industries have spent their careers chasing volume with (at best) incremental changes to existing projects, they lack the mind-set and skills needed for groundbreaking commercialization.

An institutional commercialization capability requires a cadre of trained and experienced commercialization experts who are both capable of the deep analytics needed for strategic segmentation and creative enough to generate novel business models. There are few non-executive roles in most companies where these skills coexist, so it is necessary to carefully screen for the role and to provide heavy training (usually in apprenticeship on commercialization projects). Furthermore, depending on the frequency of product launches at a company, 12 to 18 months of apprenticeship may be required. While this training may appear daunting, the silver lining is that the skills for successful commercialization are often helpful in senior-management positions.

The mind-set and expectations of senior management are also critical to successful commercialization. When making innovation investments in chemicals and materials, executives must recognize that commercialization is a long process, taking as little as one to two years to attain appreciable volume for simple line extensions in existing markets and lasting seven or more years for breakthrough projects in unfamiliar markets. While it takes less time when

[1] Polyethylene terephthalate.

the right skills and activities are in place, this is not an activity that starts in one quarter and pays off in the next. From the outset of a development project, the senior team must have the resolve to execute it.

This is not to say that a project should be left to its own devices—quite the contrary. The best projects have clear but reasonable milestones that point toward commercial success. These milestones typically include the achievement of technical goals, the establishment of the product's value proposition in core markets, and success in early applications as a path to long-term viability in core markets. Commercialization teams must be managed according to these milestones, and projects that fail to reach them must be canceled.

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The commercialization of novel materials is an inherently long process that is fraught with challenges. How these challenges are handled makes the difference between success and failure. Recognizing the failure modes—in both the value proposition and the value chain—is the first step. But if these challenges are to be managed, materials producers must continue the tactical launch planning that they typically do well and raise their game significantly in three major areas: strategic segmentation, market selection, and business-model creation. The companies that choose to focus on building institutional capabilities in these areas can create a strategic advantage in launch timing: avoiding the commercialization pitfalls can cut up to half the time required for a new material to succeed, and it increases the likelihood of adoption. Both of these factors will dramatically improve return on innovation spend, driving improved profits and stronger shareholder value.

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