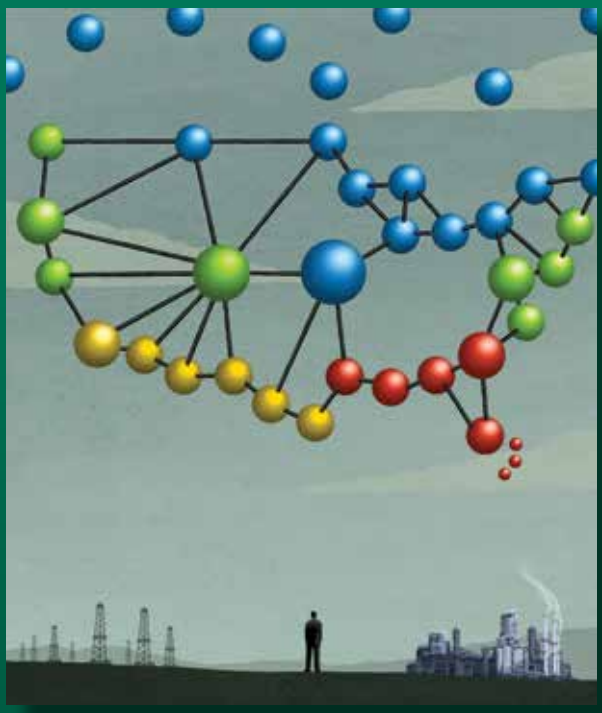
North American Chemicals 2020

Capturing Opportunities in the Revitalized Industry



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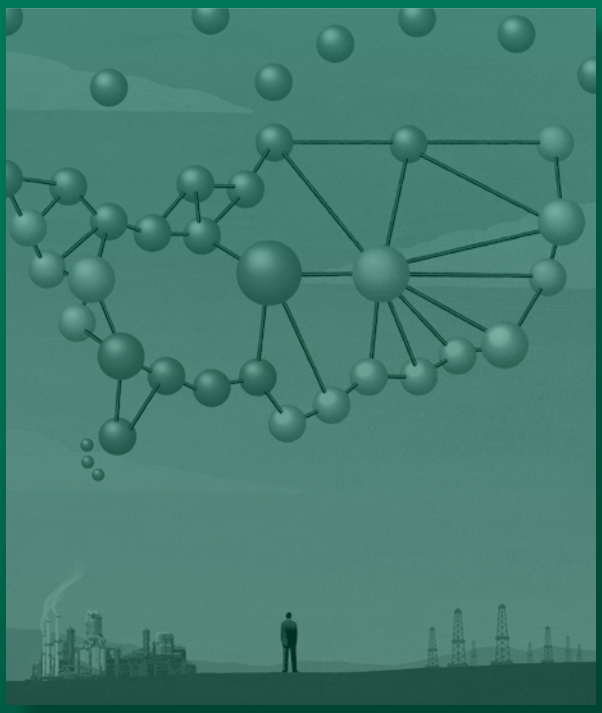

NORTH AMERICAN CHEMICALS 2020

CAPTURING OPPORTUNITIES IN THE REVITALIZED INDUSTRY

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INTRODUCTION

The chemical industry in North America is experiencing a once-in-a-generation renaissance. The growth rate of this large and diverse industry tends to track GDP, but a confluence of factors is expected to accelerate the industry's growth relative to the overall economy during the next five to ten years. By the end of this period, the U.S.—representing more than 80 percent of the North American chemical market—will be a larger net exporter of chemicals than it is today.

A major rebalancing of supply and demand is driving the favorable growth outlook for chemical production in North America and creating clear targets for investment:

- On the supply side, the availability of low-cost natural gas and natural-gas liquids (NGLs), driven by the shale boom, is improving the fundamental economics of U.S. chemical production relative to the rest of the world. From 2010 through early 2015, announced capital investments in U.S. chemical production relating to shale gas amounted to more than $130 billion.

- On the demand side, the chemical industry will benefit from the revitalization of manufacturing industries in the U.S. This trend toward reindustrialization—encouraged by cheap energy and attractive productivity-adjusted labor rates—will increase domestic demand for chemicals as inputs into other sectors of the economy by at least $10 billion to $21 billion.

- The industry's segments will not benefit uniformly from this rebalancing. A few segments (such as commodity polymers) will enjoy benefits relating to both supply and demand. In other cases, the advantages will be mainly on the supply side (bulk petrochemicals, for example) or the demand side (polyurethane, for example). Some segments (such as pharmaceuticals) are unlikely to be affected.

The recent plunge in crude oil prices is not likely to alter these market dynamics or eliminate the feedstock advantages enjoyed by North American companies.

The industry's revitalization will have significant implications for corporate portfolios and the industry's structure during the next five years. Companies will restructure their portfolios and make deals to, for example, increase specialization, focus on their core businesses, or expand their presence across the value chain.

What will set apart the winners from the rest in this era of abundant opportunities? The best-performing chemical companies in North America during the next decade will be distinguished by their ability to anticipate the challenges and prepare to capture value in this revitalized landscape. To shape their corporate agendas, executives will need to consider a set of questions at the company level:

- How will the surging supply of low-cost natural gas and NGLs affect the economics of our sourcing? Do we know our near- to medium-term requirements for feedstock sourcing? Have we considered the need for on-purpose production of chemical building blocks and the potential advantages of developing the related technology?

- What opportunities will the U.S. manufacturing renaissance create for our company? Are we ready to support manufacturing segments as they grow organically or return to the U.S.? Have we evaluated the requirements for new investments in production capacity or sales and marketing capabilities?

- Which of our products will be affected most—and which will be affected least—by the rebalancing of supply and demand? Are we positioned to enter secondary markets for our products if the high level of investment in North American capacity results in oversupply domestically?

- Have we identified our company's ideal corporate-portfolio structure? How can we restructure our portfolio to maximize the company's valuation in the evolving environment? Are we ready to make bold moves as opportunities to acquire or divest business units present themselves?

- Is our innovation portfolio optimized to capture opportunities arising from the changing economic conditions? Does the portfolio strike the right balance of product innovation, process innovation, and alternative feedstock technology?

- How are our competitors adjusting their strategies to respond to the changing supply-and-demand dynamics?

- What opportunities will foreign chemical players and other investors pursue in North America, and how should we be prepared to respond strategically?

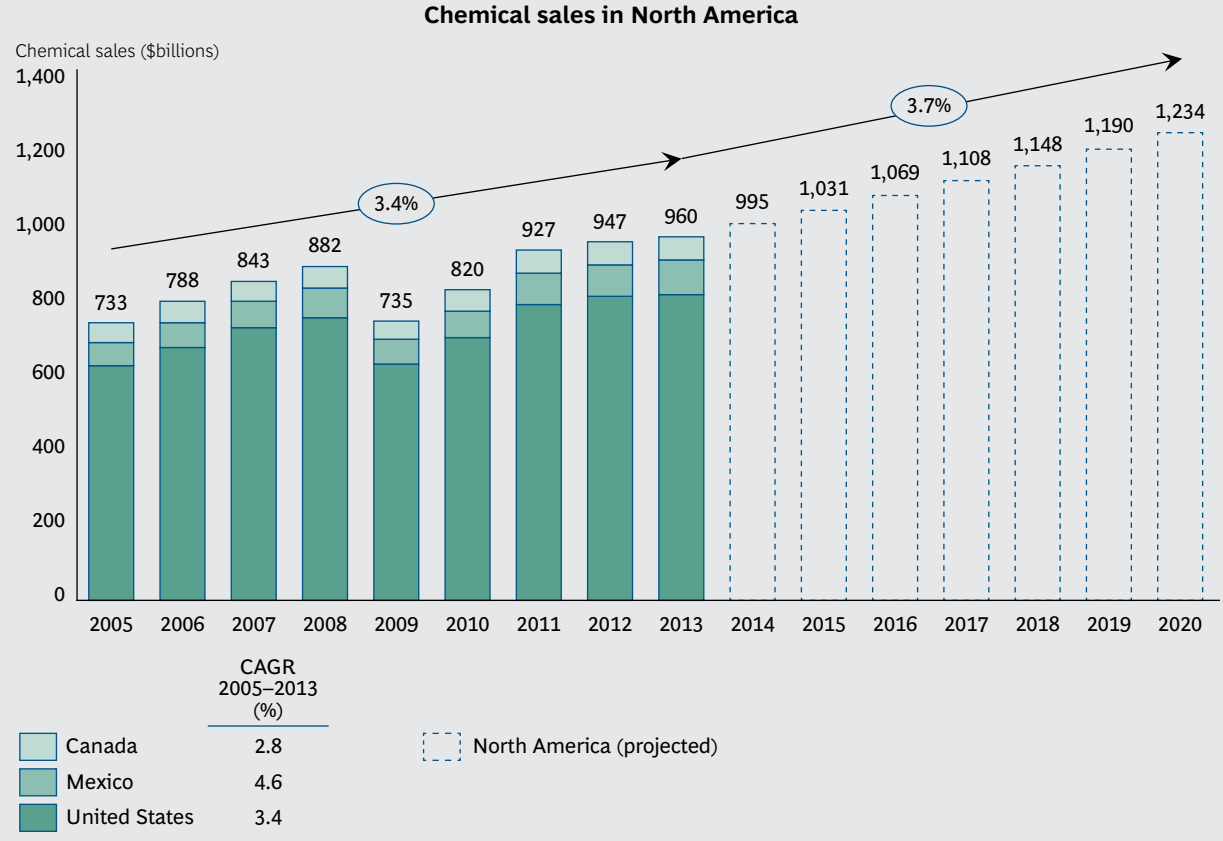
To provide context for answering these questions, this report examines in depth the revitalization of the industry as a result of the rebalancing of supply and demand and the implications for corporate portfolios. It then turns to the specific actions companies should be prepared to take to capture their share of the industry's strong growth.

A MAJOR REBALANCING OF SUPPLY AND DEMAND

The North American chemical industry is massive, with sales close to $1 trillion in 2014. Annual sales are expected to exceed $1.2 trillion by 2020. (See Exhibit 1.)

Segments of the overall market can be grouped into six major clusters: bulk chemicals, polymers, additives, formulation businesses, fine chemicals, and inorganic specialty materials.

EXHIBIT 1 | Rapid Growth Will Drive Sales Topping $1 Trillion



Sources: American Chemistry Council's *Guide to the Business of Chemistry 2014;* BCG analysis.
Note: Sales are defined as apparent consumption: production plus imports minus exports.

We developed the six clusters by grouping segments on the basis of similar key success factors, such as feedstock and scale advantages, end markets served, and formulation expertise.

The six clusters are composed of 56 segments that represent most major chemical-production activity. (See Exhibit 2.) These are generally discrete market segments within the chemical industry, although some, such as rare earths, are not typically considered to be part of the chemical industry. Additionally, because they are interconnected, the market segments overlap to some extent; for example, many water-soluble polymers are ingredients of water management chemicals. In some cases, we have separated different elements of the same industry because each element has a well-defined value chain or competitive structure.

Industry revenues are concentrated in relatively few of these segments. (See Exhibit 3.) Segments in fine chemicals, bulk chemicals, polymers, and formulation businesses are considerably larger than segments in inorganic specialty materials and additives.

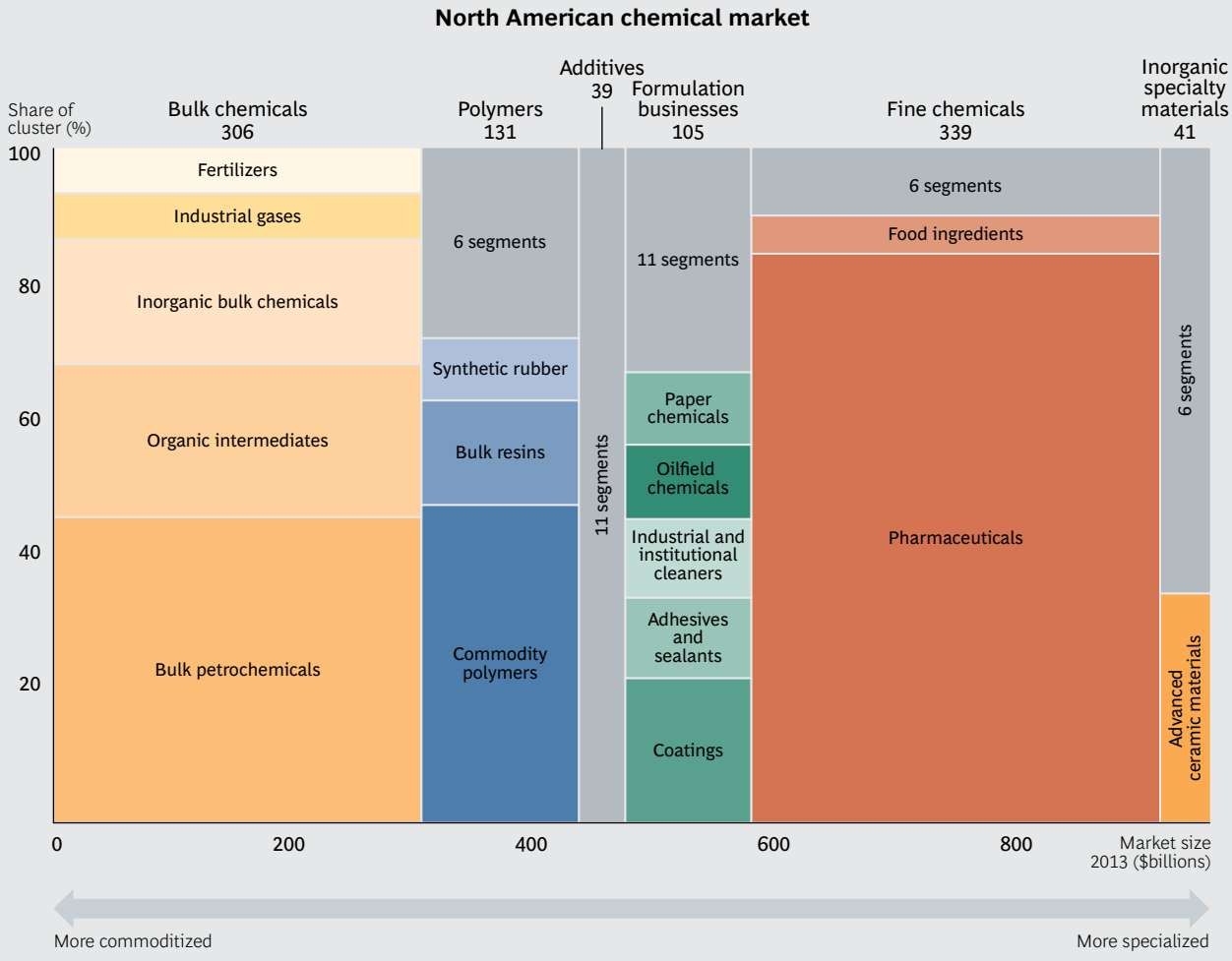
To varying degrees and in different ways, each of the 56 segments will be affected by favorable supply-and-demand developments in the near term.

Exhibit 2 | The Market Comprises 56 Segments Within Six Clusters

Chemical clusters	Segments							
More commoditized ↓								
Bulk chemicals	Bulk petrochemicals	Fertilizers	Industrial gases[1]	Inorganic bulk chemicals	Organic intermediates			
Polymers	Bulk resins	Commodity polymers	Engineering plastics	High-performance composites	High-performance polymers			
	Polymeric membranes	Polyurethane and precursors	Synthetic rubber	Water-soluble polymers				
Additives	Antioxidants	Biocides	Coatings and adhesive ingredients: additives and pigments	Coatings and adhesive ingredients: resins and solvents	Commodity surfactants	Corrosion inhibitors		
	Flame retardants	Inorganic fillers	Lubricating-oil additives	Plastic additives	Specialty surfactants			
Formulation businesses	Adhesives and sealants	Coatings	Concrete admixtures	Explosives and blasting agents	Industrial and institutional cleaners	Leather chemicals	Mining chemicals	Oilfield chemicals
	Paper chemicals	Printing inks	Rubber-processing chemicals	Specialty coatings	Synthetic dyes	Synthetic lubricants	Textile chemicals	Water management chemicals
Fine chemicals	Agrochemicals	Cosmetic chemicals	Enzymes	Feed additives	Flavors and fragrances	Food ingredients	Pharmaceuticals	Pharmaceutical excipients
Inorganic specialty materials	Advanced ceramic materials	Catalysts	Electronic chemicals	Inorganic bulk pigments	Inorganic specialties	High-performance fibers	Rare earths[1]	
↓ More specialized								

Source: BCG analysis.
[1]Not typically considered a chemical segment but included here to be comprehensive.

EXHIBIT 3 | Revenues Are Concentrated in a Few Segments



Sources: American Chemistry Council; The Freedonia Group; Grand View Research; BCC Research; IBISWorld; IHS; MarketsandMarkets; Morgan Stanley; Transparency Market Research; Deutsche Bank; Guggenheim Partners; William Blair; Société Générale; U.S. Department of Agriculture; U.S. Geological Survey; company investor-relations material; BCG analysis.
Note: Data are 2013 estimates. The 16 largest segments are listed above; see Exhibit 2 for the full list of segments in each category.

Shale Gas Creates Supply-Side Abundance

The development of shale resources has increased the supply of natural gas and NGLs in North America. (See "For Further Reading" later for BCG publications discussing the outlook for energy availability in North America.) The abundant resources will promote competitive prices for natural gas and NGLs for many years. In the medium term, through the early 2020s, historically low prices for NGLs, especially ethane, will drive the market dynamics discussed below. We believe the North American chemical industry's feedstock advantages are sustainable, notwithstanding the recent sharp decline in crude-oil prices. (See the chapter "The Continuing Feedstock Advantage.")

For the major chemical building blocks and their derivatives, the cost advantages in this environment are determined by the extent to which prices of each base hydrocarbon differ between North America and other regions and by the specific production process. Consider the following examples:

- The reduced prices for inputs are most beneficial for producers of methane derivatives (ammonia and methanol, among others). The feedstock advantages will allow them to become some of the most competitive producers globally.

- Ethane-based production of ethylene has gained a strong advantage over naphtha-based production. While the price of

ethylene continues to be set by higher-cost, naphtha-based production, the availability of ethane from shale resources allows U.S. ethylene producers to shift to an advantaged raw material as well as a production process that requires less capital, has lower operating costs, and generates higher yields. As new capacity hits the market, ethylene derivative producers and end customers could benefit from a modest decline in the cost of ethylene if value migrates downstream. (See the sidebar "How Might Supply-Side Developments Redistribute Value Along Chemical Production Chains?")

- Other important building blocks—such as propylene, butenes, and butadiene—have

HOW MIGHT SUPPLY-SIDE DEVELOPMENTS REDISTRIBUTE VALUE ALONG CHEMICAL PRODUCTION CHAINS?

Supply-side developments could result in the redistribution of value along North American chemical production chains. Several factors will come into play in determining the extent to which value migrates along each chain.

In process industries, the processing step with the most constrained capacity tends to capture the most value in the production chain. In the North American ethylene chain, ethylene production captures the most value today, because there is not enough steam-cracking capacity to consume the available supply of low-cost ethane. However, polymerization capacity continues to grow, both in North America and globally. Producers in the U.S. and the Middle East are building capacity to serve export markets, while Asian producers seek to serve domestic demand. As the industry builds new capacity, utilization rates could decline and the market could see an oversupply of ethylene, polyethylene, or both. These developments could shift value downstream to polymer processors or even end customers.

We believe it is unlikely that significant value will migrate downstream in the North American ethylene chain, for two reasons.

First, we estimate that less than 7 percent of new ethylene capacity in the U.S. will be merchant production that would bring more ethylene into the market, because most new cracker projects will be intended for captive derivative capacity. Thus, the additions to gross capacity will not affect the supply-and-demand balance of U.S. ethylene to a great extent.

Second, regardless of how much new ethylene-derivative capacity is built, U.S. ethylene prices will continue to be linked to the global price of ethylene, which is set by naphtha-based production. This linkage between U.S. and global ethylene prices is attributable to global trade in easily transportable, commodity-type derivatives like polyethylene.

There is a greater chance of value migration for propylene and butadiene. Prices have increased but could stabilize over the medium term as more on-purpose production capacity comes onstream, especially for propylene. However, if there is too much new propylene capacity, the least competitive plants could struggle to remain profitable. Propylene consumers could benefit as a result.

For some derivatives of propylene, butenes, and butadiene—such as fuel additives and synthetic rubber—increased and more volatile input prices have already passed through the product chain. This has compressed the margins of some downstream players (such as manufacturers of synthetic rubber) that have not been able to charge higher prices to end customers. In some cases, manufacturers have shifted to materials that have product chains with lower costs and less volatility. For example, some makers of coatings and adhesives have substituted vinylics for acrylics as an ingredient.

become scarcer, resulting in higher, and often more volatile, prices. Traditionally, these other important building blocks were produced as by-products of refineries and naphtha-fed steam crackers. However, because U.S. steam crackers are shifting to ethane as feedstock, the availability of naphtha by-products has declined. Going forward, the increased use of on-purpose production, especially for propylene, could stabilize prices for an extended period.

- Aromatic hydrocarbons in the BTX stream (mixtures of benzene, toluene, and the three xylene isomers) have also become scarcer, because they, too, are produced as by-products of refineries and steam crackers. The declining availability of naphtha by-products has reduced the supply of these aromatic hydrocarbons, thereby driving costs higher for BTX derivative producers. Additionally, several developments in the North American refining sector have increased the value of aromatic hydrocarbons as blendstock for motor gasoline. Although producers of BTX derivatives have experienced higher input prices, they have not always been able to pass along these cost increases to their customers. Their ability to pass through the higher costs has depended on the supply-and-demand balance of each derivative and the availability of functional substitutes in other product chains.

Three Guiding Principles for Understanding the Effects

How will these supply-side developments in base chemicals affect the broader North American chemical landscape? The answer depends on many factors, including individual production chains and technologies and company-specific levels of integration. At a high level, three guiding principles can be applied to understand how the 56 chemical segments will be affected.

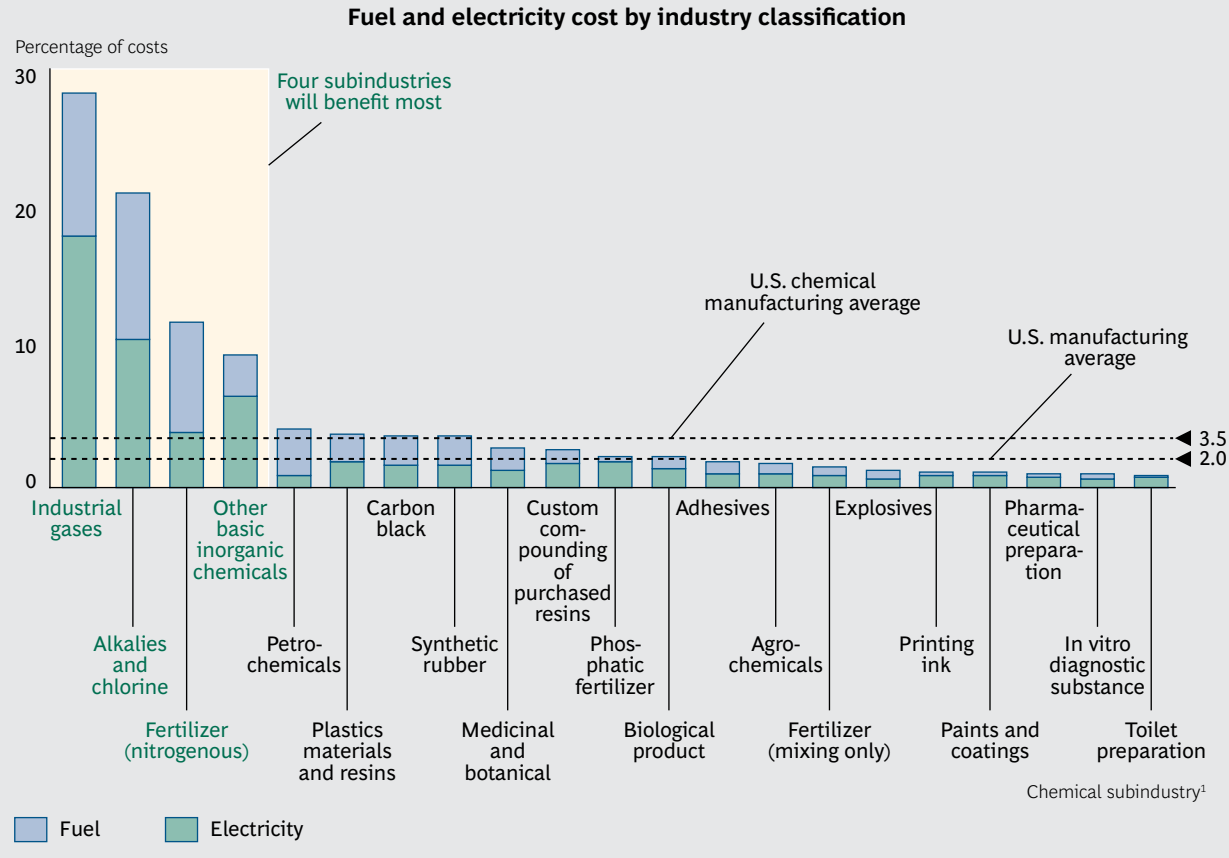
Inorganics' benefits depend on the energy requirements of production. The production of inorganic chemicals will not benefit directly from lower-priced base hydrocarbons. But, because of their highly energy-intensive production processes (energy costs represent more than 10 percent of production costs), four inorganic-chemical industries will benefit from lower power prices: industrial gases, alkalies and chlorine, nitrogenous fertilizers, and other basic inorganic chemicals. (See Exhibit 4.) U.S. industrial power prices are likely to remain low as inexpensive natural gas promotes the transition to new gas-fired generating capacity at the same time that many U.S. coal plants are retired. However, even highly energy-intensive inorganic chemicals will benefit less than organic chemicals from supply-side developments, because the cost of their feedstock will not have changed.

Upstream chemicals will see greater benefits than chemicals produced downstream.

Organics' benefits depend on the mass content of building blocks. For organic chemicals, the extent of benefits will be determined by the mass content of advantaged base chemicals. For example, the lower cost of ethylene will give polyethylene a cost advantage over polyvinyl chloride (PVC), assuming that one chemical company operates the full value chain in each case. Polyethylene is nearly 100 percent ethylene by mass, whereas each PVC monomer is 43 percent ethylene and 57 percent chlorine by mass. Although PVC will also benefit from lower chlorine costs (chlorine production is energy intensive), the impact will not be enough to offset polyethylene's cost advantage.

Upstream segments capture more value. Upstream chemicals (those closer to the building blocks) are more likely to experience greater benefits from supply-side abundance than chemicals produced further downstream in the value chain. For example, among engineering resins, polyacetal (made directly from methanol) will likely experience a greater cost advantage than polycarbonate (which has more raw materials and requires a multistep synthesis). Base chemicals (commodity chemicals typically one step removed from feedstock) will experience greater benefits than intermediates, while specialty

EXHIBIT 4 | Lower Power Prices Will Benefit Inorganic Chemicals with High Energy Costs in Production



Sources: 2011 U.S. Census Economic Survey; BCG analysis.
[1] Chemical subindustries are defined on the basis of 2007 North American Industry Classification System codes.

and application-driven chemicals will see the least impact.

Base chemicals' advantages arise for two reasons.

First, owing to their overall cost structure, base-chemical producers benefit more from lower input prices than specialty-chemical producers. Base-chemical producers' costs mainly relate to feedstock, and because their plants are large, manufacturing overhead costs tend to be low on a per-unit basis. Conversely, specialty-chemical companies invest substantially in R&D, marketing and sales, technology, and application development. They also have smaller plants, some of which use labor-intensive batch-production processes. This cost structure means that lower prices for raw materials have a relatively smaller impact on specialty-chemical producers' financial performance.

Second, U.S. producers of base chemicals generally benefit from attractive, marginal supply economics. In many cases, base chemicals are global commodities with prices set in higher-cost regions, typically because they are produced using higher-priced base hydrocarbons. As a result, U.S. base-chemical producers can keep the lion's share of the feedstock cost advantage without having to pass through the lower costs to their customers, which have limited alternatives. These favorable marginal supply economics explain why U.S. base-chemical production has become so attractive for new investments. For each company, the decision to pass the cost advantage downstream is a strategic question rather than an economic necessity.

Applying the Principles

By applying the guiding principles to the 56 chemical segments, we have identified 12

chemical segments likely to experience a cost advantage. These are mainly base chemicals (one or two steps from the chemical building blocks) and polymers produced only a few steps from base chemicals. (See Exhibit 5.)

Companies in segments that benefit from cost advantages should anticipate that new domestic capacity will be built to produce these chemicals. The amount of new capacity built to produce a given chemical will depend on several factors, including the extent of the landed-cost advantage in consuming markets, the existing North American trade balance, the anticipated supply of low-cost feedstock, and product-specific considerations, such as the product's transportability and whether it is a commodity or specialty product.

One factor spurring greater long-term demand for chemicals is the "reshoring" trend.

For example, imported products that now enjoy supply-side advantages (such as ammonia and urea) will likely be displaced by domestically produced chemicals as more new capacity is built. Manufacturers using the new capacity can take advantage of low raw-material prices but still sell the product at a higher price linked to the price of imports. For exported products (such as polyethylene), enough new capacity could eventually be built to consume the supply of advantaged feedstock and thus decrease U.S. manufacturers' cost advantage.

If the addition of new capacity changes the trade balance for a product, value may shift along its production chain. The pricing dynamics could change as the balance of supply and demand shifts; however, dramatic swings from a significant net-import position to a significant net-export position are likely to be unusual. Such a shift requires depth and liquidity in the global market and a landed-cost advantage for exports, as well as prices that are determined by an abundance of high-cost capacity around the world. Product characteristics also matter—formulation chemicals designed to meet specific customer requirements are less likely to be exported to global markets than base chemicals and merchant intermediates.

The emergence of shale gas also creates significant opportunities to create long-term corporate value through innovation. North American chemical companies already place a high priority on innovation and surpass their global competitors in applying best practices, which positions them to be early innovators and thus capture a first-mover advantage. (See the sidebar "Accelerating Growth Through Innovation.")

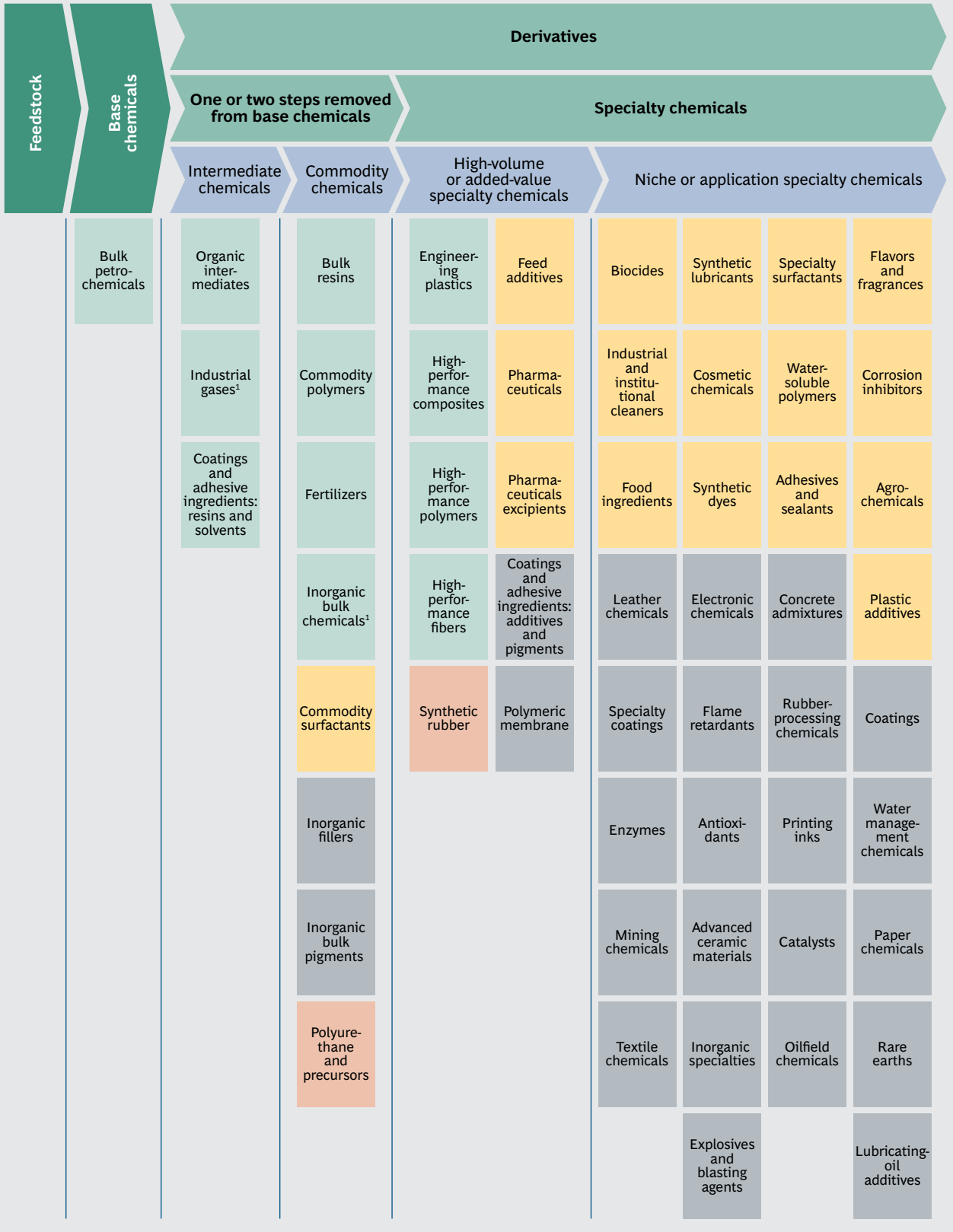
"Made in America" Drives Higher Demand

Because the chemical industry touches nearly all other sectors of the economy, it has typically grown in line with GDP. But we expect that the North American chemical industry's growth will outpace GDP for the rest of the decade. We estimate compound annual growth in demand for its products at a rate of 3.7 percent from 2013 through 2020, compared with 2.0 to 2.5 percent compound annual growth for GDP in the NAFTA countries.

The supply-driven price declines occurring in some segments will not be the only factor spurring greater demand for chemicals over the long term. The industry can also thank the trend of "reshoring": more-competitive landed costs will entice many industries to bring their production base back to North America from traditional low-cost countries, driving North American demand for the chemicals that serve these industries.

Labor-intensive industries will be drawn back by the declining labor-rate differential between the U.S. and China, and energy-intensive industries will be attracted by cheaper energy prices in the U.S. relative to the rest of world. The benefits of domestic production—including shorter supply chains and less dependence on volatile crude prices—will be hard for many industries to resist. (See *The Shifting Economics of Global Manufacturing: How Cost Competitiveness Is Changing Worldwide,* BCG report, August 2014.)

EXHIBIT 5 | Twelve Segments Will Capture the Greatest Supply-Side Benefits



Source: BCG analysis.
[1]Supply-side benefits owing to high energy intensity.

ACCELERATING GROWTH THROUGH INNOVATION

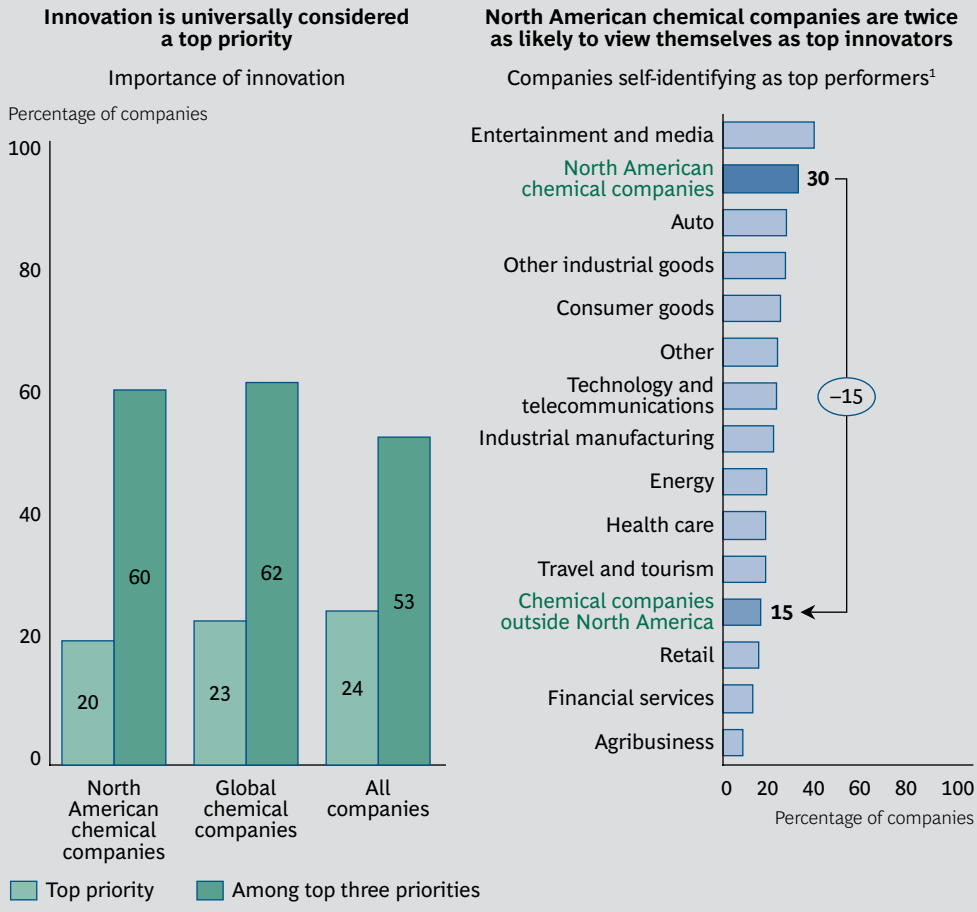
Over the next decade, North American chemical companies will use innovation to accelerate their rate of growth, the most important source of long-term corporate value creation.

Excelling at Innovation

The 2013 BCG Global Innovators Survey found that innovation is a top priority for North American chemical companies and that they are performing well. Approximately 60 percent of these companies regard innovation as one of their top three priorities, and approximately 30 percent consider themselves to be best-in-class innovators. (See the exhibit below.) About 60 percent planned to increase innovation spending in the coming year. Their innovation efforts have a broad set of goals, including creating new products and offerings, entering new markets, and achieving sustainability objectives.

The survey also found that North American chemical companies' innovation processes are mature. These companies outpace their global competitors in employing best practices such as setting clear objectives, timetables, and priorities and estimating financial benefits. They also excel in practices relating to product launch, such as developing realistic plans and involving

North American Chemical Companies Consider Themselves Top Innovators



Source: 2013 BCG Global Innovators Survey.
Note: More than 1,500 companies participated in the survey, including more than 400 in industrial products and processes.
[1]Companies were asked to rate their performance as innovators on a scale of 1 to 10; top performers are those with a rating of 9 or 10.

ACCELERATING GROWTH THROUGH INNOVATION (continued)

the manufacturing function early on. Tracking customer feedback stands out as an area for improvement.

The survey findings support our view that North American chemical companies are well prepared to pursue innovation opportunities. Their R&D productivity is high, they have access to major innovation hubs and world-class universities, and the number of patents and the availability of world-class scientists and engineers remain high. Despite cutbacks in traditional government funding for academic research, the industry can fill the gap by supporting blue-skies research. North American companies' close ties to their customers and strong understanding of their needs will guide future innovation efforts.

Building on these advantages, North American chemical companies have already assumed global leadership in several innovative technologies, such as enzymes, and the number of recent patent applications for these technologies suggests that this leadership will persist. Enzymes remain the key connection between biology and other areas of engineering, having tremendous implications for the health care, materials, food, and energy industries. From 2008 through 2012, more than 1,000 enzyme patents were filed in North America, and the number of filings grew at an annual rate of 12 percent. Knowledge hubs for enzyme technology are growing in Boston, San Francisco, and San Diego.

Capitalizing on the Shale Revolution

Companies that apply their innovation capabilities to create additional value from the surging supply of shale gas can seize a tremendous competitive advantage—bearing in mind, however, that the shale revolution will affect the major chemical production chains differently. Many innovation opportunities will require significant investments, but the current economics create incentives to pursue them.

Three types of innovation opportunities stand out:

- Replacing petrochemical processes with biochemical and enzymatic processes, to take advantage of lower input costs for biofeedstocks and the ability to run plants at lower temperatures and pressures
- Developing new products as technical substitutes for more expensive alternatives—for example, glass-reinforced polyolefins have been developed as stronger and less expensive substitutes for engineering plastics in automotive applications
- Introducing technologies, or improving the economics of existing technologies, for using natural gas or NGLs to produce on-purpose olefins and aromatics; companies can explore revolutionary opportunities that bridge production chains by using low-cost feedstock to produce these building blocks and derivatives, which have become more expensive as the availability of naphtha by-products has declined

The potential for reshoring is high in seven industries: appliances and electrical equipment, computers and electronics, fabricated metal parts, furniture, machinery, plastics and rubber (manufactured products, not inputs), and transportation. We project that the total incremental increase in chemical demand resulting from reshoring by these seven industries will range from $10 billion to $21 billion by 2020. (See Exhibit 6.)

Our analysis was limited to examining the way that reshoring in these seven industries directly affects incremental demand in the 56 chemical segments. The analysis omits the impact from segments that have robust do-

EXHIBIT 6 | Reshoring Will Increase Domestic Demand for Chemicals

	Plastics and rubber	Appliances and electrical equipment	Transport-ation	Computers and electronics	Furniture	Machinery	Fabricated metals	**Total**
Imports reshored by industry ($billions)	8-16	16-34	19-32	9-51	5-10	10-32	3-10	**70-185**
X								
Material cost as a percentage of revenue	57	56	66	43	46	54	47	
X								
Chemical cost as a percentage of material costs	80	30	15	10	25	7	7	
=								
Incremental demand for chemicals, 2020 versus 2012 ($billions)	**3.5-7.4**	**2.7-5.6**	**1.8-3.1**	**0.4-2.2**	**0.6-1.2**	**0.4-1.2**	**0.1-0.3**	**10-21**

Sources: U.S. Census Bureau's Economic Census industry costs; American Chemistry Council; BCG's *Made in America* analysis; BCG analysis.
Note: Any apparent discrepancies in the totals are the result of rounding.

mestic demand without reshoring as well as the indirect chemical demand generated by reshoring.

As shown in Exhibit 6, the plastics and rubber industry will be responsible for the largest share of the incremental increase. We project that $8 billion to $16 billion of imports will be reshored, resulting in $3.5 billion to $7.4 billion in incremental demand for chemicals domestically. Appliances and electrical equipment will be responsible for the second largest share of the incremental demand increase. Our projections indicate that $16 billion to $34 billion of imports in this industry will be reshored, corresponding to $2.7 billion to $5.6 billion in incremental demand for chemicals.

Regardless of the extent of reshoring activity, robust domestic growth in a wide range of industries will drive higher demand for chemicals. For example, increased production of shale oil and natural gas has boosted demand for a number of oilfield chemicals used in hydraulic fracturing (fracking), including proppants, biocides, and slickwater or polymer additives (typically surfactants and gels). We believe much of this demand is likely to be met domestically because the largest components of fracking fluids have relatively low value-to-weight ratios and cannot be imported economically. Other chemicals may see increased demand in the U.S., but this domestic demand could potentially be served by foreign production.

Because the effects of the surge in manufacturing activity will be concentrated in only seven segments of the economy, some companies will be affected significantly more than others. It is perhaps no surprise that polymer manufacturers will be most affected given that the plastics and rubber industry should experience the greatest increase in demand stemming from the surge in reshored activity. Additionally, plastics are an important component for other reshored industries. For example, the appliances-and-electrical-equipment and transportation industries have replaced many metal components with plastics, typically engineering resins and high-performance polymers, to reduce manufacturing costs and product weight and improve product performance, among other reasons.

As shown in Exhibit 7, five polymer segments should capture significantly higher revenues

EXHIBIT 7 | Five Polymer Segments Will See the Most Incremental Demand from Reshoring Activity

		Industry								
		Plastics and rubber	Appliances and electronic equipment	Transportation	Computers and electronics	Furniture	Machinery	Fabricated metals	**Total ($billions)**	**Incremental demand, 2020 versus 2013 (%)**
	Incremental demand 2020 ($billions)[1]	**5.4**	**4.2**	**2.5**	**1.3**	**0.9**	**0.8**	**0.2**	**15.3**	**1.6**
Bulk chemicals	Bulk petrochemicals	○	○	○				○	0.3	0.2
Polymers	Bulk resins	○	○	○	○	○	○	○	1.7	8.1
	Commodity polymers	○	○	○	○	○		○	5.6	9.0
	Engineering plastics	○	○	○	○	○	○	○	1.1	11.6
	High-performance composites	○	○	○	○	○	○	○	1.0	14.6
	High-performance polymers	○	○	○	○	○	○	○	0.2	9.5
	Polymeric membranes	○	○	○	○	○	○	○	0.3	9.0
	Polyurethane and precursors	○	○	○	○	○	○	○	0.9	11.0
	Synthetic rubber	○	○	○	○		○	○	1.3	11.2
	Water-soluble polymers	○	○	○	○	○	○	○	0.5	7.5
Additives	Coatings and adhesive ingredients: additives and pigments	○	○	○		○	○	○	0.2	4.4
	Coatings and adhesive ingredients: resins and solvents	○	○	○		○	○	○	0.2	1.8
Formulation businesses	Adhesives and sealants	○	○	○		○		○	0.0	0.3
	Coatings	○	○	○		○	○	○	0.2	0.8
Inorganic specialty materials	Electronic chemicals	○	○	○	○			○	0.8	16.5
	Inorganic bulk pigments	○	○	○				○	0.1	0.9

○ Bubble size = $1 billion

Sources: U.S. Census Bureau's Economic Census industry costs and bill of materials; American Chemistry Council; BCG's *Made in America* analysis; BCG analysis.
Note: Reflects end-industry demand only. Does not include induced demand for base chemicals and intermediates from end-market demand. Any apparent discrepancies in the totals are the result of rounding.
[1]The demand in this row is the midpoint of the projected range.

as incremental demand from reshoring adds substantially to domestic demand:

- Commodity polymers—$5.6 billion in incremental demand, adding 9.0 percent to existing demand; incremental demand from reshoring should increase the growth rate of this segment from approximately 1.5 percent per year in 2013 to nearly 3.0 percent per year in 2020
- Bulk resins—$1.7 billion in incremental demand, adding 8.1 percent to existing demand
- Synthetic rubber—$1.3 billion in incremental demand, adding 11.2 percent to existing demand
- Engineering plastics—$1.1 billion in incremental demand, adding 11.6 percent to existing demand
- High-performance composites—$1.0 billion in incremental demand, adding 14.6 percent to existing demand

In these polymer segments, which are largely mature, demand from reshoring is likely to increase the underlying growth rate by at least 1 percent per year from 2013 through 2020. For existing chemical companies, these findings point to opportunities to grow both organically and inorganically in businesses that serve key manufacturing sectors of the U.S economy. The growth in demand during the next five years will promote a higher return on investment (ROI) from building new plants (independently or in a joint venture). The chemical industry's above-average growth will also increase the value of M&A opportunities.

Similarly attractive opportunities are available to chemical companies considering expansion into adjacent segments or investors seeking to enter the chemical industry. Companies can grow organically by entering segments that have synergies with their current businesses—arising from common production chains or end markets, for example. They can also expand their portfolios using M&A to enter the fastest-growing segments, such as high-performance composites.

Which Segments Will Benefit Most?

The impact of supply-and-demand developments will vary by industry segment. (See Exhibit 8.) Companies should consider these wide-ranging effects as they determine their investment priorities.

Supply and Demand Benefits. Chemical companies should give highest priority to segments that benefit from both decreasing supply costs and growing markets. Competition could be intense, however, because many players will enter these segments, recognizing that the required manufacturing technology is readily available and the products are generally commoditized. These segments include the following:

- *Bulk Resins.* Vinyl resins will benefit most.
- *Commodity Polymers.* Polyethylene and polyvinyl chloride will benefit most; polypropylene may benefit least.

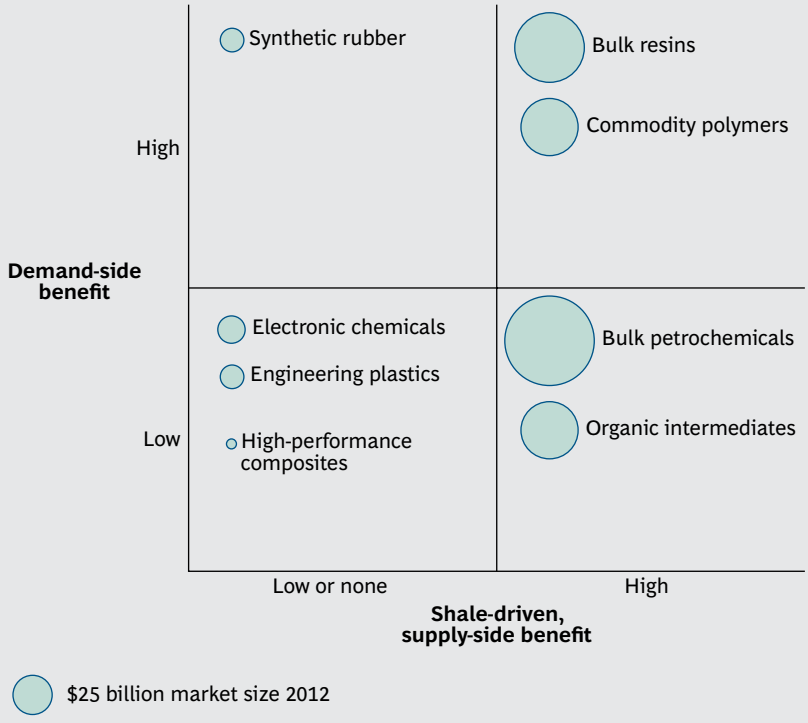
Primarily Supply Benefits. Supply-side changes are altering the fundamental economics of some industry segments. Other chemical companies that procure these segments' products as feedstocks should consider whether now is the time to integrate backward in the value chain to capture the margin that their suppliers are likely enjoying. And these segments may see an uptick in demand stimulated by the growth of other segments. For example, demand for bulk petrochemicals or industrial gas may be stimulated as new chemical plants become operational to serve polymer demand.

The industry's above-average growth will increase the value of M&A opportunities.

Segments capturing primarily supply-side benefits include the following:

- *Bulk Petrochemicals.* Ethylene will benefit most; propylene, butenes, and butadiene have historically been negatively affected.

EXHIBIT 8 | The Impact of Supply-and-Demand Developments Varies by Segment



Source: BCG analysis.

- *Organic Intermediates.* Ethylene and methanol derivatives will benefit most. These derivatives include ethylene dichloride and vinyl chloride monomer, acetic acid and the acetate chain, and intermediates with other strong links to these base chemicals.

Primarily Demand Benefits. Three segments will capture only limited benefits on the demand side, while generally experiencing limited or no benefits on the supply side; synthetic rubber will enjoy greater demand-side benefits but will generally capture limited or no benefits from supply-side developments:

- *Electronic Chemicals.* Photochemicals, acids, and bases will benefit most.
- *Engineering Plastics.* Demand-side impact will be more common because most engineering plastics are several steps downstream from base chemicals. However, specific resins like polyacetal should see substantial supply-side impact.
- *High-Performance Composites.* Carbon- or aramid-fiber reinforced composites should benefit from increased demand, while the resin matrix (primarily epoxy) should see limited supply-side benefits.
- *Synthetic Rubber.* All types will see a demand-side benefit. Most will experience supply-side challenges because they are butadiene derivatives; however, others, like ethylene propylene rubber, may see a supply-side benefit.

THE CONTINUING FEEDSTOCK ADVANTAGE

The recent plunge in the price of crude oil has led industry participants and market observers to consider whether the feedstock advantage that North American chemical companies have gained from the boom in shale oil and gas is sustainable and long lasting. We believe that this advantage will continue and that the market dynamics discussed in the preceding chapter will not be significantly affected.

Pricing Dynamics Spurred Investment

The attractiveness of North America–based production of major chemical building blocks and their derivatives, especially methane and ethane derivatives, is based on two somewhat interdependent factors:

- *The Low Price of Natural Gas and NGLs (Especially Ethane) in Absolute Terms.* Because ethane is a by-product of natural-gas drilling, it tends to trade at its marginal disposition in the market. Since 2012, the supply of U.S. ethane has greatly exceeded the market's ability to consume it. As a result, the price of ethane has fallen to its fuel equivalent, which is historically low per gallon and per British thermal unit (BTU).

- *The High Price of Heavy Feedstock Relative to Natural Gas and NGLs.* Heavy feedstocks are derivatives of crude oil. When crude oil traded consistently above $90 per barrel, from 2011 through 2014, the ratio of oil price to gas price on a barrel-of-oil-equivalent basis was often more than 3 to 1 and reached as high as 9 to 1.

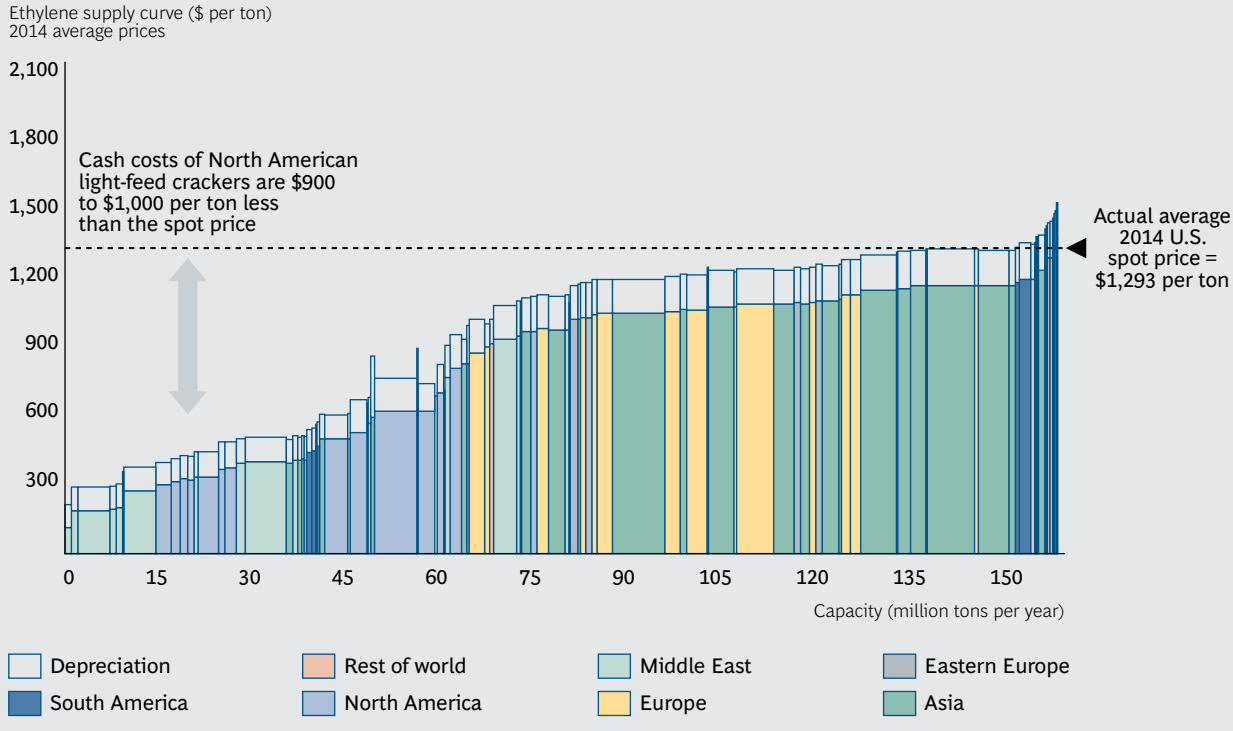
These factors combined to create a substantial advantage for U.S. chemical production—for example, U.S. ethylene producers using ethane enjoyed cash margins of nearly $1,000 per ton. (See Exhibit 9.) These pricing dynamics spurred a tremendous amount of investment in gas-based production capacity, as product prices globally continued to be set on the basis of utilizing heavy-feedstock capacity in production.

The Oil Price Plunge Has Limited Effects

From the last quarter of 2014 through the first quarter of 2015, the price of crude oil declined rapidly and sharply, by more than 60 percent from its highs. Natural gas prices also declined, and the ratio of oil price to gas price decreased toward 3 to 1. Some in the industry feared that construction of gas-based production capacity in the U.S. might be halted even before the first new units became operational.

Around the globe, some petrochemical projects were canceled or delayed indefinitely, including several greenfield projects and expan-

Exhibit 9 | North American Ethylene Producers Enjoy a Significant Feedstock Advantage



Sources: Nexant; Thomson Reuters Datastream; BCG's Petrochemicals Supply Curves Model.
Note: "Light feed" refers to ethane or a mixture of ethane and propane feedstock.

sions in the Middle East and North America and a gas-to-liquids project on the U.S. Gulf Coast.

In our view, the recent plunge and volatility in the crude-oil market may cause new investors to reconsider or delay announcing new projects or put off initiating construction. However, we believe most projects that have already broken ground, or are close to doing so, are likely to proceed.

Two reasons support our conclusion.

First, although we do not expect a significant, sustained recovery in oil prices in the near to medium term, the low prices reached in January 2015 are not likely to be sustainable over the long term. (See "Lower, and More Volatile, Oil Prices: What They Mean and How to Respond," BCG article, January 2015.) In the medium term, prices below $50 per barrel for Brent crude support only 34 percent of planned production additions through 2020. In the long term, reinvestment economics require that oil prices exceed $70 to $80 per barrel, depending on how the cost structure within the entire energy industry evolves. Many OPEC countries are running budget deficits at current oil prices, which is sustainable in the medium term but not forever.

Second, the long-term fundamentals supporting the opportunity for investors in new projects are still in place, including low-cost, abundant U.S. shale gas and NGLs:

- The feedstock dynamics in the U.S. that are driving the availability and low cost of natural gas and NGLs are not materially affected by low oil prices. Shale oil drilling has slowed but drilling for shale gas, which creates the majority of NGLs, has not. In the U.S., approximately 1,500 trillion cubic feet of natural gas (the equivalent of 30 years' supply) is extractable at costs below $5 to $6 per thousand cubic feet. In fact, the decline in the production of associated gas from shale oil may actually drive incremental demand for shale gas. The oversupply of U.S. ethane is not affected by low oil prices and, combined with the declining price of natural gas, has meant that

ethane has actually become cheaper per gallon and per BTU. Our forecast for the ethane supply-demand balance indicates that the oversupply will continue, which suggests that ethane will trade at the historically low fuel value for years to come.

- Product prices will still be set on the basis of naphtha-based production, which is a more expensive production route than using ethane at or near its fuel value. Naphtha's value is trending lower, in line with crude oil and the North American gasoline trade balance; however, the price difference between naphtha and ethane is still substantial, as is its impact on the economics of ethylene production. Our research indicates that the global ethylene supply curve flattened as of January 2015, but U.S. producers still earn cash margins of approximately $500 per ton. If crude-oil prices recover, naphtha prices should recover as well, which would increase ethane's cost advantage.

- Market demand is still strong. Most of the projects announced relate to the production of base chemicals, polymers, and intermediates. Growth in these product segments is generally driven by global GDP, and other products cannot be readily substituted for them. Ethylene alone was a 133-million-ton market in 2013 (as measured by demand) and had been growing at 3 to 4 percent annually. Multiple world-scale steam-cracking complexes are required each year to maintain current operating rates.

- The lower crude-oil price may ease cost pressures for petrochemical projects. In 2013 and 2014, the large number of new projects simultaneously planned in the U.S. heightened investors' concerns about project overage risks with regard to both cost and time to completion. However, these risks may be mitigated, because the slowdown in shale oil drilling may divert skilled labor and engineering, procurement, and construction capacity to projects along the Gulf Coast.

- Capital continues to be available. Interest rates remain low and project financing is plentiful, whether for strategic investors with big balance sheets or consortia of financial investors looking to get involved.

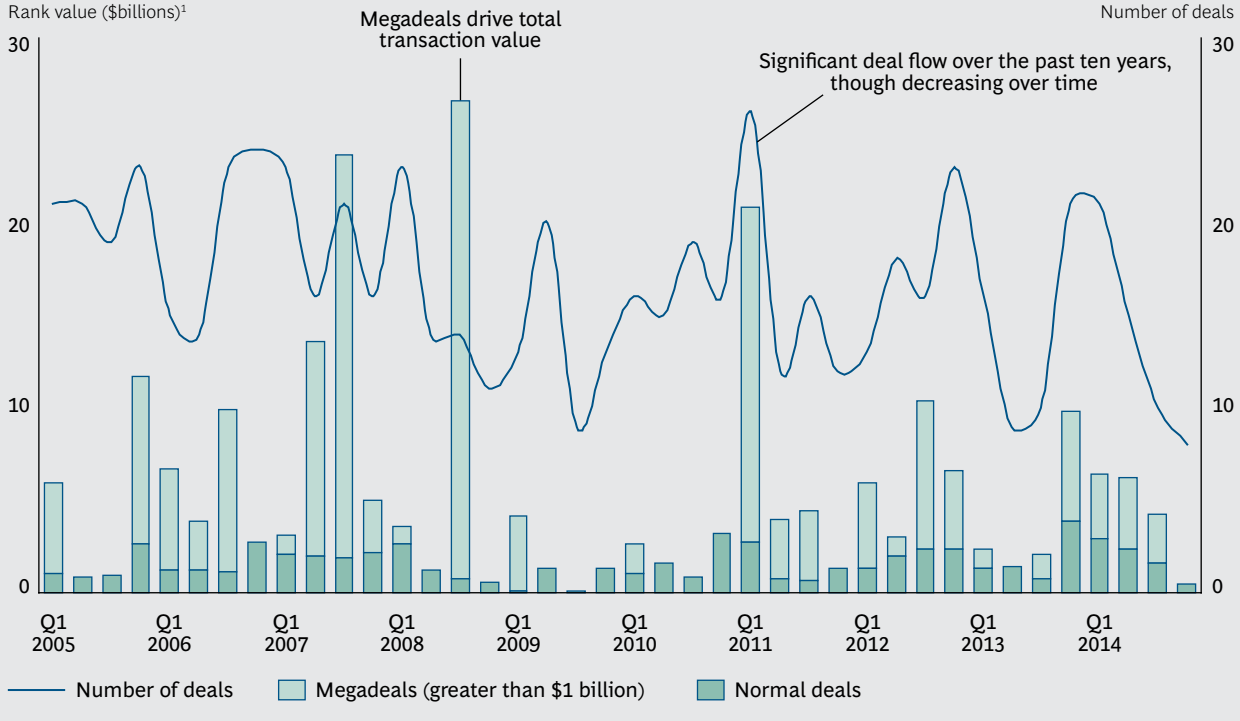
It is also important to note that crude-oil prices appear to have stabilized above the price many analysts believed was the floor (approximately $40 per barrel). So, if projects have not been canceled yet, they are unlikely to be canceled in the future. Indeed, new project announcements have resumed as crude-oil prices have started to recover and stabilize. Moreover, many new projects are not expected to come onstream until 2017 or 2018. Depending on how quickly crude-oil prices recover, the low-price environment may not even affect these projects' economics.

IMPLICATIONS FOR THE INDUSTRY'S STRUCTURE

THE INDUSTRY'S MARKET DYNAMICS will encourage a continuation of the corporate restructurings that have already brought major changes to the chemical industry, within and outside North America. The past ten years have seen several waves of deal activity, which have varied in terms of the number of deals and their magnitude. (See Exhibit 10.)

Although the number of deals remains below prerecession levels, the value of deals has re-

EXHIBIT 10 | Waves of Deal Activity Are Punctuated by Megadeals



Sources: Thomson ONE; BCG analysis.
Note: Announced M&A deals from January 1, 2005, through December 31, 2014, with a North American chemical company involved as buyer, seller, or target and a publicly disclosed deal value.
[1]Rank value includes the target's net debt.

bounded in recent years. Megadeals (exceeding $1 billion) represent a substantial share of transaction value—10 percent of deals account for 80 percent of value. Deals involving North American chemical companies also tend to be larger than in the rest of the world, and the fluctuations in these deals' annual value during the past decade have followed a pattern similar to that of other process industries.

Given chemical companies' size and prominence in the overall economy, trends in capital markets are a factor in deal activity. For example, activist investors have targeted major chemical companies amid the recent overall increase in shareholder activism. To respond to activists' pressure and improve valuations, some chemical companies have announced major cost-cutting programs or made divestitures and other moves to significantly restructure their portfolios.

Deal-Making Objectives

Four objectives underlie the deal activity in the chemical industry.

Clarifying the Portfolio Story. Companies acquire or divest businesses to support a clearer narrative for investors regarding growth, capital returns, or specialization. These companies typically want to conform to one of several archetypes, such as a high-growth specialty business or a cash-generating commodity business. This trend is expected to continue as specialty players seek to grow or to access attractive new markets and as commodity players pursue scale.

Some diversified chemical companies are making moves to align more precisely to either the specialty or the commodity archetype. Recent examples include DuPont's acquisition of Danisco and divestiture of its performance-coatings business; Dow Chemical's acquisition of Rohm and Haas, divestiture of Styron, and planned divestiture of its chlor-alkali assets; and Ashland's transformation from a commodity chemical company and refiner to a specialty material company.

Strengthening the Core Business. Companies opportunistically pursue deals to acquire technology, market access, or scale with the objective of strengthening their core business. Recent examples of this ongoing trend include PPG Industries' acquisition of SigmaKalon Group, Huntsman's acquisition of Rockwood Holdings' titanium dioxide and performance additives businesses, Albemarle's acquisition of the remainder of Rockwood Holdings' businesses, and Merck KGaA's acquisition of Sigma-Aldrich. Recent serial acquisitions by large chemical distribution companies also illustrate this trend.

Deals involving North American chemical companies tend to be larger than in the rest of the world.

Capturing Value-Chain Opportunities. Companies, including foreign investors, seek to capture opportunities by moving upstream or downstream in the value chain. Securing access to shale gas has been a common objective for upstream acquisitions and investments, and the rate of investment (both domestic and foreign) in shale-related assets is accelerating. A recent example of an upstream move is Occidental Chemical's joint venture with Mexichem to build an ethylene cracker to support its vinyl business. Although not corporate restructurings, recent investments by Dow Chemical and Ascend Performance Materials in propane dehydrogenation reactors are also moves to capture a greater share of the value chain. To move downstream and add value to their products, many polyolefin players are looking to enter specialty segments, including compounding and other postreactor processing.

Divesting Units from Holding Companies. Diversified holding companies are divesting chemical units that lack synergies with the rest of the business. For example, in order to focus on its health-care business, Bayer has announced plans to spin off its business unit that makes polycarbonate, polyurethane, and other polymers. We expect such rationalization efforts to become more prevalent over time. Because chemical businesses are typically more capital intensive and cyclical

and require more specialized capabilities than many other businesses, many diversified companies have decided that these units are better suited as stand-alone companies or as part of a larger chemical company.

Looking Ahead

We expect companies to continue to pursue megadeals opportunistically over the next decade. The high volatility in deal value from year to year will persist, given that a variation of one or two megadeals per year can significantly affect the total transaction volume. Although portfolio realignment will remain the primary objective, restructurings in some segments could be driven by product-specific dynamics, such as product maturity levels, global or regional supply-and-demand imbalances, and access to raw materials.

When the U.S. petrochemical renaissance runs its course, sometime after 2020, the industry may see a new round of consolidation, as the source of competitive advantage will shift from feedstock to other factors, including scale and operational excellence. Private equity firms will remain market makers in the chemical industry, particularly as diversified chemical companies continue to realign their portfolios.

The overall number of deals involving a North American chemical company completed each year may continue to decrease slowly. Previously completed deals and the increased involvement of private equity firms have reduced the number of potential targets available in the chemical industry. Most of the low-hanging fruit—simpler or smaller deals—has already been picked. Additionally, the increase in interest rates anticipated by many market observers would take capital out of the market. However, the decrease in deal activity will be offset by larger investments in new capacity, as companies seek to utilize the increased supply of natural gas and NGLs.

TAKING ACTION TO CAPTURE THE OPPORTUNITIES

Although the revitalized industry offers abundant opportunities, North American chemical companies will need to position themselves appropriately to maximize their competitive advantage. These companies can lay the groundwork by taking six actions.

Plan for Near- to Medium-Term Feedstock Sourcing

Large commodity manufacturers should allocate capital to secure low-cost feedstock. By applying insights on how shale will affect their supply chains, they can identify opportunities to replace existing feedstock sources. For example, Shin-Etsu Chemical, the world leader in PVC, is considering building an ethylene plant in the U.S. Specialty chemical manufacturers should pursue deals with suppliers to improve access to low-cost chemicals. The cost of some basic building blocks may decline, but companies should seek to secure preferential pricing—through partnerships and joint ventures, for instance—before the industry-wide cost reductions occur.

Increase On-Purpose Production

Companies should anticipate the need to develop capabilities for on-purpose production of chemicals, such as butadiene, that have been produced in decreasing quantities as NGLs replaced naphtha as steam cracker feedstock.

Although a large share of on-purpose production is likely to continue to occur through traditional chemical and petrochemical routes, biotechnology will increasingly become an attractive alternative. Biotechnology routes allow companies to rely on alternative feedstocks, typically sugars and natural oils and acids, to create chemical products and intermediates. Examples include biobased production of ethanol, other alcohols and diols, and diacids.

Companies can capture competitive advantage by shifting to biobased production.

Companies can capture three important competitive advantages by shifting to biobased production. First, using alternative feedstock allows a company to diversify its exposure to economic cycles affecting input prices. Second, because bioindustrial facilities can operate at lower temperature and pressure than traditional chemical plants, they are often less capital intensive. Third, the minimum scale required for biobased production is lower than for traditional production,

which creates new opportunities for all players and will likely motivate additional M&A activity.

Prepare to Meet Demand from High-Growth Industries

To effectively serve downstream industries as they are reshored to North America or grow organically, chemical companies will need to make new investments in manufacturing capacity and sales and marketing capabilities. Some companies may be able to leverage existing global relationships with chemical consumers; for others, the opportunity is completely new. The best time to take action is before the major changes take hold. By gaining a scale advantage ahead of their competitors, the first movers will position themselves to maximize their ROI and capture the lion's share of the returns.

Get Ready to Serve Secondary Markets for Products

The surge in investments in cost-advantaged production capacity in North America creates the potential for oversupply in the domestic market, especially in bulk chemicals and polymers. To mitigate the risks, chemical companies may find it essential to increase trade with the rest of the world. Companies should recognize that establishing new or additional supply lines between North America and the rest of the world (particularly rapidly developing economies) takes time and can be complex. Joint ventures or distribution agreements are usually required to capture the opportunity.

Identify the Ideal Corporate-Portfolio Structure

In examining their corporate portfolio structure, companies should critically assess their objectives and financial targets and have the courage to reshape their portfolios accordingly. Companies also should be ready to make bold moves as opportunities to acquire or divest business units present themselves. They should continue to explore megadeals and look for opportunities to acquire business units currently owned by holding companies.

Reevaluate Existing Innovation Portfolios

As costs decline and new processes, technologies, and materials become cost-effective, companies need to examine whether their innovation portfolio strikes the right balance among process innovation, product innovation, and alternative-feedstock technology. In the current environment, long-term bets on advantaged sourcing can be as valuable as newly developed products. For example, technologies for converting methanol to olefin or liquefied petroleum gas to aromatics are both likely to be valuable over the long term.

North American chemical companies are operating in an era marked by both abundance and uncertainty. Wildcards that could again shift the balance of power in the chemical industry include the development of unconventional resources outside North America, regulations and taxes that undermine North America's cost advantage, and breakthrough innovations in industrial biotechnologies that change the cost position of individual companies.

To succeed, each company must not only identify how supply and demand are changing but also gain a deep understanding of how these developments will affect its own business segment and other segments upstream and downstream in the value chain. The winners will apply the insights to capture value proactively, and respond agilely, as these developments reshape the chemical industry in the years ahead.

FOR FURTHER READING

The Boston Consulting Group has published other reports and articles on the topics covered by this report that may be of interest to senior executives. Examples include the following.

Two Sides of the Coin: The Impact of Low Oil Prices on Downstream Oil
An article by The Boston Consulting Group, June 2015

Lower, and More Volatile, Oil Prices: What They Mean and How to Respond
An article by The Boston Consulting Group, January 2015

The Ongoing Rise of Shale Gas: The Largest Revolution the Energy Landscape Has Seen in Two Decades
An e-book by The Boston Consulting Group, October 2014

The Shifting Economics of Global Manufacturing: How Cost Competitiveness Is Changing Worldwide
A report by The Boston Consulting Group, August 2014

The 2013 Chemical Industry Value Creators Report: How 20 Years Have Transformed the Chemical Industry
A report by The Boston Consulting Group, May 2014

Seizing the Opportunity in U.S. Petrochemicals
An article by The Boston Consulting Group, April 2014

Specialty Chemical Distribution-Market Update: Strategic Imperatives for Suppliers and Distributors
A Focus by The Boston Consulting Group, April 2014

Natural-Gas-Liquid Derivatives: The Energy Tsunami's Next Wave
An article by The Boston Consulting Group, July 2013

Natural-Gas Liquids: The Implications of the Next Energy Tsunami
An article by The Boston Consulting Group, October 2012

Made in America, Again: Why Manufacturing Will Return to the U.S.
A Focus by The Boston Consulting Group, August 2011

NOTE TO THE READER

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