Global petrochemicals disruptions

Business model innovations for a dynamic market
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Over the last few years, the global chemicals industry has undergone a series of large-scale disruptions. On the demand side, a shift to faster-growing Asian markets and the increasing commoditization of specialty chemicals continue to play out. On the supply side, factors such as shale gas developments in the U.S. and coal in China have altered the feedstock mix for petrochemicals producers. Together, these trends are challenging the business models for five key building blocks in the industry: methanol, ethylene, propylene, butadiene, and aromatics.

For the methanol value chain, the staggering demand growth is likely to sustain current price levels. Methanol players in the U.S. and the Middle East should consider converting methanol to olefins and/or propylene, and consider building additional methanol capacity to take advantage of cheap feedstock where available.

Ethylene will continue to be oversupplied from locations such as the U.S., driven by cheap gas. European crackers — which still rely on more expensive naphtha as feedstock and are far from the growing demand base in Asia — must streamline their operations to improve efficiency and develop new higher-value derivatives.

The propylene market will continue to experience supply constraints in the short term, leading to price imbalances for some derivatives. In response, U.S. companies should consider integrating upstream into new on-purpose routes. European producers need to rely on tight integration with refineries and product and feedstock innovation to remain competitive.

The butadiene value chain remains largely driven by the tire industry, and some manufacturers in Asia are now placing the complete value chain (from butadiene through tires) in a single location. Rubber and tire manufacturers need to consider a similar integration strategy to solidify their butadiene sourcing and reduce costs.

Finally, aromatics continue to be in short supply, challenging refiners to increase yield/production through extraction technologies. Similarly, users of aromatics should weigh investing in stand-alone reformate units to secure supply.
The global chemicals industry continues to experience major disruptions. The trends on the demand side have been playing out over the past decade. Performance and specialty chemicals — which have traditionally offered higher margins — are increasingly becoming commoditized. Overall demand continues to shift to higher-growth markets in Asia, challenging established supply centers in Europe and North America. Global demand is expected to sustain healthy growth rates that will be 1.5 times the rate of expansion of the world economy.

By contrast, shifts in supply have been more recent and more volatile, leading to larger imbalances. The shale gas phenomenon in the U.S. and the use of coal as a feedstock are both relatively new, only having an impact on the market in the last five years. Nonetheless, they have already fundamentally altered the petrochemicals sector. Furthermore, the possible emergence of new players with conventional sources of feedstock, such as Iraq and Iran, could also alter the supply situation.

The implication of these shifts varies by region and by petrochemicals value chain. In North America, ethylene is replacing naphtha in crackers in growing volumes, due to widely available and inexpensive shale gas, and the overall petrochemicals industry is gathering momentum again. In Europe, however, the situation is more difficult. Crackers in Europe still depend heavily on naphtha as a feedstock. These producers are geographically removed from the supply of lower-cost ethylene (from U.S. shale gas or Chinese coal), and from high-growth markets in Asia. As a result, European producers are increasingly vulnerable.

Meanwhile, the Asian industry is being fueled by rapid economic expansion and increasing demand for petrochemicals end-products (although demand softened slightly in 2013).

In the Middle East, producers that once dominated the petrochemicals market based on cheap and plentiful natural gas are now receiving lower allocations, even as many countries in the region seek to develop downstream industries. The impetus is understandable. Governments in the Gulf Cooperation Council countries need to diversify their economies by moving away from their traditional reliance on natural resources and
related industries such as petrochemicals to generate much-needed employment opportunities for nationals. The result, however, is that Middle East producers have had to shift to naphtha as a feedstock.

In the aggregate these supply and demand disruptions are leading to greater price volatility and disrupting established value chains. Shale gas in the U.S. and coal in China have led to widely available, low-cost ethylene, which in turn has reduced the supply of heavier molecules such as propylene, butadiene, and benzene. Aromatics are even more constrained, due to the closure of some refineries. All have experienced large price swings compared to ethylene (see Exhibit 1).

Responding to these market dynamics requires looking at specific considerations for each of the major petrochemicals value chains: methanol, ethylene, propylene, butadiene, and aromatics.

Exhibit 1
Petrochemicals prices have become more volatile

Middle East producers have had to shift to naphtha as a feedstock.
Methanol — it’s all about China

Both methanol supply and demand are expected to grow at very high rates in coming years, driven by China, which is the leading producer and consumer of methanol worldwide. This will remain the case through at least 2017 (see Exhibit 2, page 7). The current demand for methanol is driven by formaldehyde, dimethyl ether, acetic acid, and methyl tertiary butyl ether (MTBE), which together account for more than two-thirds of global demand. In the near future, however, most of the demand growth will likely be from motor fuel blending and olefins conversion — both primarily in China.

On the supply side, methanol operating rates (i.e., capacity utilization) in China remain low, at just 50 to 55 percent. The primary reasons are significant overcapacity (many Chinese operators have expanded aggressively, often to secure coal-mining rights), insufficient scale of some plants (which are not economical enough to operate under current prices), scarce water in some regions, and expensive feedstock (typically anthracite instead of coal).

This excess methanol capacity in China is not expected to pose a threat to methanol prices in the short term, due to robust demand growth. It does, however, represent a cap on methanol price increases, because higher methanol prices could make some of the idle high-cost capacity economically viable.

These methanol supply/demand dynamics require a strategic response from producers of methanol and its derivatives.

In the near term, U.S. producers should consider building additional methanol capacity to take advantage of the excess feedstock — both local and low-cost — from shale gas. Longer term, both U.S. and Middle East producers should consider downstream integration into methanol-to-propylene (MTP) or methanol-to-olefins (MTO) processes.
Exhibit 2
China will dominate the methanol market

Methanol Supply
(capacity, million tons per annum)

Methanol Demand
(by end-use, million tons per annum)

Speculative capacity\(^1\)

\[\begin{align*}
| & 2012 & 2017 \text{ forecast} \\
\hline
\text{China} & 96 & 160 \\
\text{U.S.} & 48 & 140 \\
\text{Europe} & 15 & 14 \ (	ext{MTO/MTP}) \\
\text{Others} & 27 & 25 \ (	ext{Gasoline/Fuel blending}) \\
\end{align*}\]

\[\begin{align*}
| & 2012 & 2017 \text{ forecast} \\
\hline
\text{MTO/MTP} & 63 & 105 \\
\text{Gasoline/Fuel blending} & 83 & 45 \\
\text{Others} & 62 & 16 \\
\end{align*}\]

\(^1\) Speculative capacity is capacity that has been announced in investment plans but is unlikely to be built. Note: MTO = Methanol-to-olefins, MTP = Methanol-to-propylene.

Source: Strategy&
Such a strategic move would make economic sense if those players believe that olefin prices are likely to increase more than methanol prices. At today’s price levels, players are somewhat indifferent between a pure methanol play and an MTP/MTO play (see Exhibit 3).

*Exhibit 3*

**Margins for pure methanol and MTP plays are similar**

Propylene versus Methanol Prices and Margins, 2000–2012

Wavy dotted line represents the methanol–propylene price combination at which the same margin is achieved with either a pure methanol play or an MTP play

- Dots are a quarterly price combination of propylene and methanol

Note: MTP = Methanol-to-propylene

Source: Strategy&
The same integration response applies to Chinese producers, which could also move downstream to capture potentially higher margins from methanol-based derivatives. More fundamentally, Chinese producers should consider investments in process innovation, to improve the coal-to-methanol (CTM) process (see Exhibit 4).

Exhibit 4
North American methanol players will take advantage of low-cost gas to increase capacity

Implications for Methanol Players

-**Gas-based players**
-**Coal-based players**

<table>
<thead>
<tr>
<th>Region</th>
<th>Methanol</th>
<th>Derivatives</th>
<th>Olefins / Polyolefins</th>
<th>Business Model Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>Increased capacity</td>
<td>Integration into olefins (MTO/MTP)</td>
<td>- Leveraging low-cost gas to increase capacity</td>
<td></td>
</tr>
<tr>
<td>Middle East</td>
<td></td>
<td></td>
<td></td>
<td>- Consider forward integration into olefins</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>Coal-based technology</td>
<td>Integration into derivatives</td>
<td>- Improving technology (cost, environmental impact, water usage)</td>
<td></td>
</tr>
</tbody>
</table>

1 MTBE, formaldehyde, acetic acid

Source: Strategy&
Ethylene — a story of continued surplus

The shale gas boom in the U.S. has resulted in a significant supply of low-cost ethylene over the last few years. With additional ethane — a source of ethylene — possibly coming online from Russia (through natural gas liquids, or NGLs), Iraq (through associated gas), and China (through shale gas), ethylene is likely to be in abundant supply for the next decade, generally at the lower end of the cost curve (see Exhibit 5).

Exhibit 5
Ethylene will be oversupplied in 2025, with European and Asian crackers under cost pressure

Projected Ethylene Cost Curve in 2025 (assuming oil price of US$90/barrel)

Note: Width of bar is capacity in tons.

Source: Strategy&
This will have significant implications for existing producers of ethylene and derivative chemicals, depending on the primary feedstock they are currently using — typically NGLs, naphtha, or coal—and their proximity to end customers (see Exhibit 6). For example, U.S.-based companies that sell ethylene derivatives have easy access to shale gas as a feedstock, but they are geographically removed from the growing demand base in Asia. As a result, they need to take steps such as upstream integration into NGLs to ensure they can remain competitive with newer, cheaper ethylene sources coming online.

### Exhibit 6
European players will consider tighter integration with refineries and moving to higher-value-added products

<table>
<thead>
<tr>
<th>Implications for Ethylene Value Chain Players</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North America</strong></td>
</tr>
<tr>
<td><strong>Europe</strong></td>
</tr>
<tr>
<td><strong>Asia Pacific</strong></td>
</tr>
<tr>
<td><strong>Middle East</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Note: NGL = natural gas liquids.

Source: Strategy&
Similarly, shale gas will put pressure on margins for European companies, which suffer from two disadvantages: older steam crackers based on naphtha and a long distance from the industry’s emerging centers of demand. Given the market environment, efficiency is critical. European producers of ethylene and its derivatives need to focus on streamlining their operations and tightly integrating with refineries to reduce costs. On the revenue side, these companies also need to drive top-line growth by investing in product innovation and developing higher-value products for their portfolio.

Middle East players, on the other hand, must also deal with local factors, such as reduced access to natural gas and a need to strengthen local industries and increase employment. The cumulative effect of these forces is downstream expansion and a shift away from gas to heavier feedstocks and liquids. In the right context, however, the shortage of gas can represent an opportunity for Middle East producers. Now that these resources are more constrained, Middle East companies will need to improve yield, operate more efficiently, use technology more intelligently, factor sustainability into their operations, and take active steps toward manufacturing excellence. The Middle East petrochemicals industry will likely undergo a wave of mergers and consolidation, especially among smaller players as they strive to achieve scale.

Finally, Asian producers of ethylene and derivatives are also likely to expand and acquire competitors in order to increase capacity and achieve scale, which is even more attractive in a growing market. Some are already using “Verbund” type plays, in which integrated petrochemicals companies can rapidly switch from one feedstock and from one end-product to another, adapting their processes in response to changing market conditions.

Propylene — supply constraints continue

The emergence of shale gas and reduced competitiveness of naphtha crackers has put the supply of propylene under significant pressure, a situation that is unlikely to change in the near term, even with some announced additions to capacity. This has led to high prices for propylene and odd price imbalances for some derivatives. For example, even as the price of propylene has risen, the price of polypropylene has fallen (see Exhibit 7, page 13). This is because the prices for polypropylene are determined by the closest substitute, i.e., high-density polyethylene (HDPE), instead of the price of its chemical components.
Exhibit 7
Propylene supply shortage compared to demand is expected to continue up to 2017

Propylene Supply/Demand and Impact on Derivative Margins

Propylene Demand (Million Tons per Annum)

<table>
<thead>
<tr>
<th>Region</th>
<th>2012</th>
<th>2017 forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>20%</td>
<td>26%</td>
</tr>
<tr>
<td>U.S.</td>
<td>21%</td>
<td>17%</td>
</tr>
<tr>
<td>Europe</td>
<td>22%</td>
<td>18%</td>
</tr>
<tr>
<td>Others</td>
<td>38%</td>
<td>35%</td>
</tr>
</tbody>
</table>

CAGR\(^1\) +6%  12%

Shortage

2017 forecast

Propylene Vs. Polypropylene Prices

\(^1\) Compound annual growth rate.

Source: Strategy&
Several on-purpose routes are emerging as propylene sources, such as propane dehydrogenation (PDH), coal-to-propylene (CTP), and olefin metathesis. We expect that these will represent the majority of capacity additions in the next few years. However, these are not easy or immediate solutions. All three have a higher cost of production. In part this is because they involve large complex facilities that take close to 10 years to develop from concept through to execution and commissioning — far slower than recent economic trends in the industry. In addition, some planned production facilities have either been delayed or canceled recently.

On the other hand, propylene demand is expected to experience robust growth of around 5 percent per year until 2018. This will lead to a shortage in propylene capacity compared to demand in the near term. In the longer term, on-purpose propylene production technologies should provide a capacity base better able to stabilize the supply/demand balance.

The business model implications for the propylene value chain are somewhat similar to those of ethylene (see Exhibit 8, page 15). Producers in the U.S. will need to integrate upstream, through the new on-purpose routes discussed above. Already, the U.S. market has seen significant PDH capacity additions based on propane from NGLs. To a lesser extent, they should consider integrating downstream, into bio-based derivatives. The opportunity here seems somewhat limited, however, given the lower margins from such derivatives.

For European companies, which are still cracking a lot of naphtha, scale and innovation will be essential. These producers will need to better integrate with refineries, in order to deliver efficiencies in feedstock sourcing and production, along with innovations that can bring new value-added derivatives to market. Because the competitive pressures in this market are so strong, European propylene producers will likely undergo a period of consolidation, as winners seek to build scale and losers exit the business.

In Asia the objective is to focus on process innovations in order to lower costs and achieve favorable economics in CTP. This is particularly the case in China where most manufacturers take advantage of the country’s abundant coal resources.

In the Middle East, investments in new naphtha cracking capacity will sustain propylene production. This is a necessary adaptation to the reduced gas allocations mentioned above. With propane limited, the region is unlikely to see much capacity from the newer on-purpose routes. Middle East players will need to develop the capabilities to ensure that they can remain competitive with heavier, liquid-based feedstock, such as the ability to run integrated plants, along with strong commercial and marketing know-how.
Exhibit 8
Asian players will seek to improve the economics of alternative feedstocks

Implications for Propylene Value Chain Players

- Securing captive supply:
  - On-purpose technologies
  - Bio routes

- Innovation-driven value-added derivatives

- Technology innovation for improving economics of alternative feedstocks

- Move toward liquid feedstock and job creation through downstream integration

Note: NGL = Natural gas liquids.

Source: Strategy&
Butadiene — the case for a move to Asia

The butadiene value chain has been among the most significantly affected by the recent supply/demand movements, resulting in extreme price volatility. The primary reason is that the butadiene market is far smaller than those of the other basic molecules (ethylene, propylene, and benzene), and minor changes in supply or demand can significantly alter the overall balance, resulting in violent price swings.

For example, butadiene prices effectively quadrupled between 2009 and 2012, because of reduced supply from naphtha crackers and a brief recovery in the tire market. (Around half of all tires are made with a synthetic product called styrene-butadiene rubber, or SBR.) High prices led European and Asian producers to add capacity, either through debottlenecking — i.e., adding extractive distillation units on existing naphtha crackers — or by building new naphtha crackers and butane dehydrogenation units. In 2013 however, global tire demand dropped once again. In conjunction with the new capacity that had just been added, this led to a glut of butadiene, and another crash in prices (see Exhibit 9, page 17).

In coming years, the most significant factor affecting the market is the growing tire industry in Asia, whose automotive market is booming. Large sections of the population are entering the middle class and so buying cars. This may lead to a recovery in butadiene prices, although the implications will vary by business model. Unlike other value chains, these implications are driven more by the type of business than by the region.

For example, we expect to see pure-play rubber producers — along with integrated rubber and tire producers — move up the value chain and build co-located facilities (butadiene through tires), primarily in Asia. The significant overcapacity in SBR, however, will have lasting effects. Pure-play tire producers may try to consolidate their market share by expanding into growth markets. Moreover, given the collapse in SBR prices, and the lingering excess capacity, integrated synthetic rubber producers are likely to exit their SBR portfolios or idle their plants in the short term.

Aromatics — the continued shortage

The benzene value chain has been affected by recent market trends in a unique way, particularly with regard to supply side constraints. Benzene’s value chain includes toluene and the xylene isomers. These collectively make up the aromatic hydrocarbons that are known as BTX. Benzene has two major supply sources: naphtha crackers and reformate units in
refineries. Coal tar distillation is the third-largest source, but it is primarily used in China. Each of these three, however, is a byproduct route, whose economics are primarily driven by the price of other products. Several on-purpose routes exist, of which toluene disproportionation (TDP) is the most commercially viable. However, the costs for these routes are still much higher than for the three primary processes.

Exhibit 9
Butadiene and SBR prices have boomed and crashed

Butadiene and Styrene Butadiene Rubber Prices (US$/ton)
Recently, each of benzene’s main supply sources has come under pressure. Whereas shale gas developments have constricted supply from naphtha crackers, the output of BTX from refineries has suffered due to increasing environmental regulations on the amount of benzene allowed in gasoline. As a result, TDP, the third byproduct route, has been the main source of “swing capacity” and has led to the largest price fluctuations (see Exhibit 10).

**Exhibit 10**
The main supply sources of benzene are under pressure

Benzene Shortage from Crackers and Refineries

<table>
<thead>
<tr>
<th>Year</th>
<th>Steam Cracking</th>
<th>Reformate Extraction</th>
<th>TDP (swing capacity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>18.1</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>17.6</td>
<td>16.3</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>19.3</td>
<td>16.2</td>
<td>3.1</td>
</tr>
<tr>
<td>2025</td>
<td>22.0</td>
<td>16.6</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Note: TDP = Toluene disproportionation.  
Source: Strategy&
Given that demand for benzene will continue to grow, driven by markets in Asia and the Middle East, producers of benzene and its derivatives will need to adopt innovative business models to deal with the shortages. As with the butadiene value chain, the specific implications for benzene are driven more by the type of business than by the geographic market (see Exhibit 11).

**Exhibit 11**

Refiners and petrochemicals players will build commercial decision-making capabilities to maximize the value of each molecule

Implications for Benzene Value Chain Players

- **Reformate, Pygas, Coal**
  - Business Model Considerations
  - Build commercial decision-making capabilities to maximize value of each molecule based on market conditions

- **Benzene, Toluene, Xylenes, Derivatives**
  - Business Model Considerations
  - Build trading capabilities
  - Build storage capabilities
  - Invest in technologies that can produce derivatives from C2/C3 value chains (e.g., MAN, MMA)
  - Invest in reformate extraction

- **End Products**
  - Business Model Considerations
  - R&D to maintain margins
  - Expand and consolidate within regions

Note: C2 = Ethylene, C3 = Propylene, MAN = Methacrylonitrile, MMA = methyl methacrylate.

Source: Strategy&
Upstream players with refineries and/or integrated petrochemicals operations should consider building commercial decision-making capabilities to maximize the value of each molecule based on prevailing market conditions. In a more dynamic environment, some refineries could benefit from shifting the liquid volume yield from their refineries to produce more aromatics and propylene. However, this requires market intelligence and agility.

Integrated aromatics players, on the other hand, might need to build up trading and storage capabilities in order to minimize the impact of raw material price fluctuations. Further downstream, they may choose to invest in production facilities such as swing reformate extraction units to protect themselves from price fluctuations, or technologies that can produce derivatives from the C2/C3 (ethylene/propylene) value chains to diversify their raw material sources.
Implications for global players

Petrochemicals companies around the world are responding to the disruptions in supply and demand by adapting their business models and building new and lasting capabilities. Broadly, these moves follow certain common themes across the value chains for all five building blocks, such as:

- Invest in, or integrate into, advantaged feedstock where possible to secure supply
- Improve scale, operational efficiencies, and value-chain integration to drive down costs
- Develop innovative new products to increase top-line revenue, and process innovation to improve profitability
- Build flexibility into business models by incorporating commercial decision-making capabilities, storage and trading capabilities, and swing production capacities to manage against price volatilities

The Middle East petrochemicals industry has a distinct role to play. The region’s petrochemicals industry has been known for its financial strength, ability to efficiently produce and market bulk chemicals, and partnering skills. These capabilities helped in the industry’s initial growth phase, which was primarily driven by access to natural gas. To maintain its position, the industry will need a different set of capabilities in coming years as it moves into naphtha cracking and downstream products.

Specifically, this will include capabilities such as Verbund — the ability to optimize production across multiple product streams on a continuous basis based on market conditions — which will be critical to maximize returns from the diverse product portfolio of the new naphtha-based production plants. Given the scope and complexity of plants being built in the region, capital projects management and execution capabilities will also be essential. Moreover, as the Middle East petrochemicals industry diversifies and moves downstream, it needs to focus on innovation — in both products and processes — to stay competitive. Finally, producers need to develop strong commercial and marketing capabilities to constantly stay abreast of customer needs and requirements. This is particularly relevant given that most end customers are in other regions.
Conclusion

Although the current disruptions and their implications for the chemicals industry seem significant, they underscore the need to address the problem from a capability perspective. The petrochemicals industry has often seen similar periods of profound change. Starting with the transition from inorganics to organics, the introduction of plastics, and the launch of material science, change is inevitable. Instead of trying to predict such changes, which is almost impossible, producers can win by building the capabilities needed to adapt to such changes, leaving them ready to compete no matter what the future holds.
1 The Gulf Cooperation Council countries are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates.
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