Flexibility and Innovation
Today’s Imperatives for Steel

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Flexibility and Innovation
Today’s Imperatives for Steel

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The steel industry faces two major challenges. The first is increased volatility in both demand and raw-material prices. Compounding these factors is the shift of consumption and production from traditional to emerging markets.

This volatility is underpinned by the movement away from traditional yearly benchmark contracts toward quarterly, or even shorter-term, pricing. Experience from other industries that have undergone this transition leads us to believe that this trend is irreversible unless there is an unexpected downturn in China. This means that companies will have to develop new skills in market intelligence and trading.

At the same time, the shift in production and consumption to developing markets leaves limited growth options for companies in traditional markets. When a business environment changes in this manner, so too do the assumptions governing company strategy.

This report looks at the ways in which the steel industry can respond to these changes. Produced by The Boston Consulting Group’s Industrial Goods practice, it follows two earlier BCG publications. It argues that it is possible for established companies to survive and prosper in the current environment. But to do so, they need to find value-generating niches. Companies can do this if they adopt an adaptive strategy that enables them to anticipate and react to changes in markets characterized by constant flux rather than stability. They can accomplish this through high levels of end-to-end value-chain flexibility and R&D. How will this work?

In the first place, flexibility will have to operate across the entire supply chain. Companies need to look at how they procure raw materials, as well as the respective value-in-use in the production process. They must make sure that products meet customer requirements and can be sold to the market.

- Short-term pricing will make it increasingly important to optimize raw-material sourcing while continuing to meet output requirements.
- Varied sourcing and sales models are likely to emerge. The established rigid system, in which companies source fixed-quality materials for a given static output mix, will be supplemented by more flexible options, as observed in other industries, such as oil and gas.

Flexibility measures will extend to an increasing emphasis on capacity management. Adjustment of blast furnace, rolling-mill, and downstream processing capacity and utilization can be used not only to achieve higher flexibility but also to realize cost savings. The recent downturn saw steel companies “learning” to handle lower blast-furnace utilization, sometimes as low as 30 percent, which is much lower than had been considered feasible.

- Companies will have to consider the tradeoff between reducing costs through complete shutdowns and decreasing utilization to respond rapidly to an upturn. Our findings, however, show a large bandwidth with little difference in the overall direct financial impact of the two measures.
- Inventory management will become increasingly important. One way to respond to increasing demand

Executive Summary

volatility and hold service levels constant is to raise inventory stocks, but this will certainly increase overall costs. Companies need to find ways of balancing safety inventory levels without risking revenue potential or increasing net working capital significantly.

In addition to these short- and medium-term changes, companies need to develop longer-term strategies that will ingrain flexibility in their culture in the same way that concepts of efficiency are ingrained.

- The creation of diversified-capacity networks by mixing integrated and electric-arc-furnace routes and units of different sizes can bring sustained benefits by balancing efficiency and flexibility.
- There will also be a role for more traditional flexibility measures as part of an evolving strategy. Resource adaptation and lean management can contribute to flexibility by reducing the fixed-cost base and making companies more capable of reacting to demand swings.

None of this is likely to happen overnight, but companies that ask themselves the right questions and apply the answers sensibly over time will rise steadily toward market leadership. The same applies to the second strand in adaptive strategy—focused innovation. The need for innovation is driven by an environment in which many companies tend to become niche or multiniche operators. In a highly fragmented industry, most companies are, for practical purposes, niche operators relying either on a geographic advantage of proximity to customers or specialist products that can be sold on global markets. This has implications for the place of innovation in company strategy.

- Rising producers in China and other developing countries will compete for established technology niches. To stay ahead, companies must innovate.
- The steel industry traditionally spends less than many other industries on R&D, but steel companies that have spent more on R&D are not always the most profitable or innovative.
- This raises some questions: What drives R&D success? How can companies ensure the efficiency and effectiveness of their R&D organization?

Answering such questions helps generate a coherent and effective strategy for focused innovation. Companies need to decide whether innovations are intended primarily to generate profit or growth, and they need to determine for each product whether they aim to be a first mover or a follower.

- How they answer these questions will define the focus areas for R&D investment and, hence, the innovation strategy required to stay ahead of the competition.
- No matter which decisions are made, many companies can still make their R&D effort more effective by aligning it with the overall business strategy.

In this report, we provide fundamental questions and a step-by-step framework outlining how companies can progress toward a fully adaptive strategy.

- Decision makers have to ask themselves whether the capabilities of their company have advanced far enough to support an effective adaptive strategy.
- If a company lacks the necessary capabilities, decision makers must then ask themselves how those capabilities are to be acquired.

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The steel industry is currently facing a broad range of challenges, such as new regulations governing carbon dioxide emissions, demographic changes, and end-customer shifts. Above all, the following two challenges present themselves and have to be faced:

- Increased volatility in demand and raw-material prices
- Continuing shift of consumption and production to emerging markets—especially China—while growth expectations in mature markets are limited

The report is structured along two topics—flexibility and innovation—because we believe that achieving excellence in these dimensions will help steel companies cope with the two challenges.

The past five years have seen significant fluctuations in raw-material prices, which continue to have a massive impact on production costs. The average cost of producing a ton of carbon steel in Western Europe in 2005 was $365. Three years later, this had risen by almost 80 percent to $655, but by 2009, it had dropped back to $425. Almost the entire switchback trajectory was attributable to fluctuations in raw-material and energy costs. These movements have been accelerated by the rapid—and, we believe, irreversible—move by raw-material suppliers from yearly contracts to quarterly benchmarking or indexing, and the trend is toward even shorter-term pricing. This has created an environment in which market intelligence and trading capability are essential to steel companies.

At the same time, economic prospects appear more uncertain than ever. Steel has already experienced immense volatility. During the boom years—from 2001 through 2007—annual growth in finished-steel consumption averaged more than 5 percent. This led to the industry’s largely “forgetting” that it is inherently cyclical. There was an absolute decline in 12 of the past 35 years, including 2009, when steel consumption was down 6.7 percent from the year before. (See Exhibit 1.)

All of this has been accompanied by a rapid and continuing shift of production and consumption to China. That China is growing in importance is hardly peculiar to steel, but the speed and magnitude of change are. In 2001, European, Japanese, and North American companies were responsible for 45 percent of world steel production, compared with China’s 18 percent. By 2009, these formerly dominant regions were down to 24 percent while China produced 46 percent, with its ten largest companies themselves responsible for 19 percent of world production.

China attained self-sufficiency in steel over the past decade. (See Exhibit 2.) Although established producers in developed countries did not therefore participate significantly in the growth in worldwide demand, driven by China, they did benefit from higher world-market prices. We expect that China will continue to be self-sufficient, in line with government policy that the country must secure its own raw-material supplies. However, there is a risk of China’s production outgrowing demand: domestic-demand expectations for the short to medium term are highly uncertain. Because this could lead to an export drive by Chinese companies, it further underlines the need for companies in developed countries to reinvent themselves to sustain their position in current markets.

The two challenges outlined above contribute significantly to increasing instability within the steel industry.
Exhibit 1. The Steel Industry Is Very Cyclical, and Changes in GDP Have a Disproportionately High Impact on Demand

Exhibit 2. China Moved from Being a Net Importer to Self-Sufficiency
Worldwide Production of Crude Steel

Sources:
1. World Steel Association; EIU country data; BCG analysis.
2. GDP is at purchasing-power parity.

Sources:
1. European Union includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.
2. Crude-steel production relative to apparent consumption.
panies are in more danger than ever of losing their place among the leaders in their sector.

Few sectors are more unpredictable or volatile than metals and mining. An internal BCG study of 64 industrial sectors revealed that in the past 30 years, only 7 sectors have had more positional volatility—the extent of their movement up or down the list of market leaders.2 Exhibit 3 depicts annual company rankings by net sales for the North American metals and mining industry. Each line represents one company and its relative net-sales ranking year by year.

The rate of change in these rankings has more than tripled over the past 25 years. This volatility is in stark contrast to the stability in the years 1950 through 1985, during which the average company changed its relative net-sales position by only 1.4 positions rather than 4.9.

In addition to that positional volatility, the BCG study shows that the metals and mining industry has been extremely unpredictable over the past ten years. Software is the only industry with a higher rate of earnings-per-share forecast errors. The high capital intensity of the steel industry also makes the cost of failure extremely high.

If anything, unpredictability is likely to be still greater over the next few years. Raw-material prices are highly volatile, and patterns of demand are uncertain. Global shifts in the balance of demand and production may well continue.

Volatile environments can undermine some of the traditional underpinnings of company strategy. These underpinnings assume a context in which companies compete in a relatively stable environment—a world in which scale, position, and capabilities drive competitive advantage. In such an environment, the traditional strategic process—analysis, followed by forecast, followed by optimization—makes perfect sense. When those assumptions cease to hold, so does a significant part of this logic.

Even more than companies in other industries, steel companies need an adaptive strategy that addresses the un-


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**Exhibit 3. Companies in the Metals and Mining Industry Show High Volatility in Sales Rankings**

![Graph showing annual company rankings by net sales for the North American metals and mining industry. Each line represents one company and its relative net-sales ranking year by year.]

**Source:** BCG analysis.

**Note:** This ranking includes only publicly listed U.S. metals and mining companies. Each line represents a company’s rank by net sales over time.
The predictability of today’s environment and the limitations of deductive analysis: they need to become more dynamic, semiempirical, and recursive. Employing an adaptive strategy means being constantly aware of possible changes in the market, being prepared to meet them as they arise, and having the ability to respond rapidly and sustainably.

To meet the challenges of the modern steel market, companies must have increased flexibility in production in order to react to volatile raw-material prices and unpredictable demand, and they must foster the innovative culture that is essential to devising the products required in a dynamic and shifting market. We believe that flexibility and focused innovation will determine whether a steel company prospers or declines.

Flexibility must be the keynote for the steel industry’s productive processes: the industry must have the flexibility to respond to the challenges created by the volatile prices of its raw materials and the increasingly uncertain demand for its products. This will not be easy. It goes against the inherent technological drive of the industry to seek stable, continuous operation in order to maximize efficiency and create constant output quality. This conflict will always be difficult to resolve. But incorporating flexibility—and the calculations and skills that come with it and, hence, dealing with this built-in conflict skillfully—will be as essential in the new environment as efficiency and quality.

This has implications for the whole production value chain. Changes cannot be made in isolation. They must be considered holistically for their impact across the entire length of the production process chain. An adaptive strategy for the new realities under which the industry operates has to take in techniques for controlling materials across the entire supply chain and managing capacity and a variety of other measures—all designed to enhance flexibility.

Such measures come under three main headings:

- **Materials**: Increased cost volatility makes it essential to have effective strategies for managing materials across the length of the supply chain. Companies need to optimize their raw-material sourcing while they continue to meet output requirements and take advantage of price spreads. In addition, they will need greater flexibility in the mix of raw materials that they use, for example, blast-furnace and electric-arc-furnace production processes.

- **Capacity**: Volatile demand means that production must be even more adjustable than before. In the short and medium term, this means adjusting blast furnace, rolling-mill, and downstream processing capacity and utilization to respond to ever-wider swings in demand, as well as optimizing inventory management. In the longer term, companies need to optimize their own capacity networks and think more about strategic partnerships.

- **Traditional Flexibility Measures**: These include measures such as adjusting to volatile demand by flexible shifting of resources, cutting internal resources to the lowest demand level, and meeting upswings by external services. Furthermore, the application of lean principles to identify and eliminate waste can reduce cycle times and, hence, increase flexibility.

### Materials Flexibility

Sourcing, production, and sales have to be linked more closely than before. If procurement identifies an opportunity, production must be able to quantify the actual value-in-use of the input materials. At the same time, production planning and sales need to make sure that products meet customer specifications and produced volumes can be sold to the market. So in place of the traditional application of pull principles only, effective strategies for flexibility in input and output materials need to look in both directions across the length of the supply chain.

Across the supply chain there are merchant markets for input materials (coal, coke, and iron ore), for intermediary products (for example, pig iron and slabs), and also for finished products (such as hot-rolled and cold-rolled coil). However, price fluctuations and traded volumes (market liquidity) vary sharply across these different merchant markets. There is great market liquidity at the raw-material and finished-product stages, while intermediate production steps (pig iron and slabs) show much lower trading volumes and indications that they might decrease further.
So it makes sense for our analysis to concentrate on the stages with the greatest liquidity—and, therefore, the highest potential for gain and loss. These are raw-material sourcing and the sale of finished products to end customers. We therefore focus on three topics: general sourcing and sales models needed to increase flexibility, possible options for securing raw materials, and flexibility in the use of input materials.

**Flexibility in Sourcing and Sales.** Steel companies traditionally purchased their raw materials—both the iron ore they processed and the coal they used as a reducing agent—on annual contracts, with a benchmark fixed for early the following year. This system survived for a long time because it suited both the mining companies and the steel producers. For the mining companies, it generated planning stability for future investments. Steel companies benefited from stable long-term supply contracts that usually matched the contracts they had with customers.

Things have changed over recent years, chiefly because of increasing demand from China and the resulting price rally for raw materials. Chinese steel producers found that they needed ad hoc supplies in order to procure sufficient raw material for their ever-growing demands, while smaller Chinese mining companies—generally unable to adhere to annual supply contracts—offered material on a short-term basis. These parallel developments led to the creation of a regional spot market and a new level of price transparency alongside the traditional annual contracts.

This coexistence of spot and benchmark contracts triggered the abandonment of the yearly benchmark system. Further impetus came from competition between the Atlantic and Asia-Pacific supply basins and a consequent preference for negotiating free on board (FOB) and cost, insurance, and freight (CIF) prices for supplies to China.

Theoretically, in an upturn, steel companies should benefit from annual contracts, as their suppliers are unable to pass through the increased prices immediately. A downturn should favor the mining companies because contract prices are higher than spot market prices. As it turned out, the declining volumes and the availability of lower spot prices meant that some steel companies did not fulfill their annual contracts. Instead, some sourced on the spot market or deferred volumes. Steel companies in developing countries were particularly likely to do this, with average contract nonperformance reaching approximately 60 percent. (See Exhibit 4.)

So mining companies did not benefit in market upturns and were not fully protected in downturns. This was one of the arguments for them to move to quarterly pricing, which is inevitably more volatile and responsive to shifts in supply and demand. By April 2010, the quarterly-pricing system had become the reality, while some mining companies argued more recently that monthly pricing should be the next step.

Our interviews with steel executives show that some believe that the shift to quarterly or even shorter-term pricing is temporary and will soon be reversed. We think this is unlikely unless there is an unexpected short- to medium-term slowdown in China, leading smaller miners to seek the greater security of longer-term price contracts. Experience from other industrial markets, such as oil and gas and thermal coal, suggests that the move to shorter-term pricing is probably a one-way street, characterized by four stages:

- **Low-Liquidity Market**: Annual or longer pricing based on benchmarks, with no intermediaries and purely physical trade
- **Hybrid Market**: A variety of prices set by a mix of benchmark and spot markets, with intermediaries such as index providers and banks entering the market, and mostly physical trade
- **Liquid Market**: Short-term spot or index pricing, intermediaries facilitating ever-shorter-term transactions and the emergence of financial techniques such as swaps and options
- **Highly Liquid Market**: Floating (weekly or daily) spot or index pricing, traders and hedge funds actively involved, and a vibrant spot and financial market with adjacent markets developing

Iron ore and metallurgical coal are close to the liquid-market phase—with indexes created and intermediaries entering the market—and with transition periods short-
Given this likelihood, steel companies need to be alert and must adjust their capabilities. The most flexible steel companies will garner serious rewards. One way for steel companies to approach this is to review the way in which they source raw materials, looking for ways to take advantage of increasing liquidity in these markets. (See Exhibit 6.)

Steel companies have traditionally operated in the rigid system, and BCG interviews confirm that it remains widespread. This is a classic “pull” system, driven by customer demand. Customers place orders under long-term—frequently yearlong—contracts for a product of fixed quality. The companies, therefore, source raw materials that meet fixed-quality requirements.

This system of long-term supply and customer contracts is what you might expect in a mature and conservative industry such as steel. With the stable conditions underpinning this approach no longer applying, companies need to consider two alternative models plus a trading add-on.

The first alternative is raw-material flexibility. This resembles the rigid model in that the end-product contract remains the same and the companies deliver constant quality. They are, however, able to adopt a more flexible approach to sourcing in order to exploit market opportunities. This allows them to process different qualities of input material while still producing output of constant quality.

The second is end-to-end flexibility. Customers still “pull” a fixed volume—perhaps 60 to 80 percent—under traditional inflexible contracts. The remaining production capacity is utilized on the basis of the price and availability of resources, “pushing” a part of the production into channels that open up opportunistically. This model suits low-cost companies better than steel producers with more demanding product portfolios, and it will further globalize the steel market.

The trading add-on option is so called because we do not yet see a fully evolved trading model as a realistic option for the steel industry. Instead, we expect it to operate as an add-on to one of the three other sourcing models. We do, however, expect to see some companies taking advantage...
Exhibit 5. Iron Ore and Metallurgical Coal Are Approaching the Liquid-Market Phase
Transition Times to Liquid Markets Are Shortening

<table>
<thead>
<tr>
<th>Year</th>
<th>Crude Oil</th>
<th>Alumina</th>
<th>Gas (North America)</th>
<th>Thermal Coal (Atlantic)</th>
<th>Thermal Coal (Pacific)</th>
<th>Iron Ore</th>
<th>Metallurgical Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>Low liquidity</td>
<td>Hybrid market</td>
<td>Low liquidity</td>
<td>Hybrid market</td>
<td>Low liquidity</td>
<td>Low liquidity</td>
<td>Low liquidity</td>
</tr>
<tr>
<td>1980</td>
<td>Hybrid market</td>
<td>Low liquidity</td>
<td>Hybrid market</td>
<td>Liquid to highly liquid market</td>
<td>Hybrid</td>
<td>Hybrid</td>
<td>Liquid to highly liquid market</td>
</tr>
<tr>
<td>1990</td>
<td>Liquid to highly liquid market</td>
<td>Low liquidity</td>
<td>Hybrid market</td>
<td>Low liquidity</td>
<td>Liquid to highly liquid market</td>
<td>Hybrid</td>
<td>Liquid to highly liquid market</td>
</tr>
<tr>
<td>2000</td>
<td>Low liquidity</td>
<td>Hybrid</td>
<td>Hybrid</td>
<td>Low liquidity</td>
<td>Hybrid</td>
<td>Low liquidity</td>
<td>Low liquidity</td>
</tr>
<tr>
<td>2010</td>
<td>Hybrid</td>
<td>Hybrid</td>
<td>Hybrid</td>
<td>Low liquidity</td>
<td>Hybrid</td>
<td>Hybrid</td>
<td>Hybrid</td>
</tr>
</tbody>
</table>

Sources: Press research; BCG analysis.

Exhibit 6. Optimized Sourcing and Sales Can Offer Value to Steel Companies

<table>
<thead>
<tr>
<th>Sourcing and sales model</th>
<th>High liquidity</th>
<th>Low liquidity</th>
<th>Solid phase</th>
<th>Finished products</th>
<th>Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Rigid system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Flexible sourcing</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3 End-to-end flexibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Trading add-on</td>
<td></td>
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</tr>
</tbody>
</table>

1At the end of raw-material sourcing, there is full flexibility, whereas at the end of finished products, there is only partial flexibility.

Source: BCG analysis.
Note: Most likely, steel companies will use the different systems in parallel.
of market opportunities by purchasing raw materials beyond their own production requirements and taking profits by selling—rather than processing—the extra supply.

Companies adopting any of the more flexible sourcing models will also need to acquire a range of new capabilities and skills, including the following:

- **Market Access.** Companies need to be able to operate in a particular market and take positions and manage relationships with multiple counterparts along their supply chain.

- **Raw-Material Market Intelligence.** They need the ability to identify inefficiencies that create profitable trading opportunities, to quantify the value-in-use of materials, and to perform operations or structure transactions that their competitors cannot.

- **Finished-Product Market Intelligence.** This demands the ability to negotiate flexible contracts with customers, as well as a deep knowledge of end-customer markets.

- **Arbitrage Trading.** This depends on the ability of companies to develop valuation skills, trading systems, knowledge of legislation, and a sophisticated capacity for risk management.

Knowing the possibilities of the sourcing and sales model and the required capabilities, steel companies need to make strategic choices about where they want to be and what they will try to achieve. The oil industry, already a liquid market, shows a wide range of approaches. Some major companies still operate on a rigid system, some have altered their approach to the extent of running a full-fledged trading model, and others run on either raw-material flexibility or end-to-end flexibility. There have been significant successes under all four models. The clear lesson, just as applicable to steel, is that there is no single best way of doing things. The challenge for decision makers is to find the best way for their companies.

**Securing Raw-Material Volume and Price.** Whatever sourcing option is chosen, the need is the same: to secure supplies in terms of volume and, or alternatively, price.

**Securing Volume.** One way to secure volume is backward integration: buying or acquiring equity stakes in mining companies or becoming involved in exploration through a joint venture. Another is to seek long-term contracts. These generally involve fixed volumes with more flexible prices, sometimes negotiated on a spot-minus-x or a cost-plus-y basis.

**Securing Prices.** This can be done through financial instruments such as iron ore swaps (which were pioneered in 2008 and are reckoned to account for 5 percent of the current spot market) or the steel futures now being traded on several markets. An alternative is a surcharge system under which raw-material prices are reviewed at points during the length of a contract and higher prices are passed through to clients as a surcharge on the base price.

Securing volume techniques is common practice for major companies, while securing price techniques is currently under development. Backward integration is increasingly being considered to counter the supplier power wielded by a small group of extremely powerful mining corporations—three companies account for about 70 percent of seaborne production—and to minimize the destabilizing effect of fluctuating prices. Newspaper reports and corporate press releases over the past few months have shown that seven major steel companies are looking seriously at backward integration.

Several company models will emerge from this process. (See Exhibit 7.) Some companies—mostly European, Japanese, and U.S. producers or small to midsize specialist-steel producers—appear likely to remain pure steel companies with a clear policy of continuing to buy raw materials from mining companies rather than investing in the mining sector. Others are moving toward—and some have attained—the integrated-participant model in which their steel-production role is supplemented by the control of mining assets and engagement in the exploration and exploitation of resources.

These differing strategies reflect the fact that while backward integration is an increasingly popular trend, it is not a universal panacea. Many steel companies are not in a financial position to buy significant shares in their raw-material suppliers.
It makes complete sense only if the company can leverage a volume or a value benefit. Volume benefits rely on the assumption that resource scarcity will continue to increase and that mining companies will limit investment and will either fail to fulfill contracts or will increase prices significantly in boom times. Value benefits occur only when the asset being acquired is undervalued, there are synergies with existing assets, the coal or ore characteristics are constant, the company has superior knowledge of the region where the mining operation is located, and superior mining capabilities within the company allow for the optimization of resource utilization.

These conditions will apply for some companies. Where they do not, backward integration will bring more difficulties than it solves.

**Flexibility in the Utilization of Input Material.** There is also considerable scope for flexibility in the utilization of raw materials in the production process. Our findings show the following:

- Flexibility can be achieved in the utilization of raw materials in key aggregates and processes.
- This kind of flexibility offers considerable cost-saving potential.
- Flexibility can also be applied to existing plant setups.
- Companies should, therefore, pursue flexibility with boldness.

Many key processes in the making of iron and steel offer—depending on equipment and operation skills—the option of varying the quality, form, or mixes of input materials. For example, coking plants can use different mixes of hard or semisoft coking coal, and blast furnaces can use mixes of various proportions of iron ore lump, pellets, and sinter. Below, we focus on examples of the raw-material flexibility of blast furnaces and electric-arc furnaces (EAFs).

**Blast-Furnace Burden Mix.** Our research shows that there is already considerable variation in the burden mix (proportion of iron ore lump, pellets, and sinter) applied to blast furnaces. These differences apply worldwide, as well as within individual regions. This shows that there is considerable scope for adjusting burden mixes in seeking the most effective and efficient formulation.

While such flexibility is already widely known in the industry, the ability to assess the cost and effects of using different materials is essential to leverage this flexibility. To analyze the cost of iron ore in different burden mixes, we compared the high-sinter burden mix of a blast furnace in Germany with the average burden-mix composition at other German plants. (See Exhibit 8.) Because the plants are all in the same country, we can assume that their raw materials are of similar quality and are comparably priced. The effect of the burden mix is clearly visible.

All other factors being the same, it is generally less expensive to produce a ton of pig iron using the mix with the higher sinter component. This led one Asia-Pacific company to invest more than $100 million in upgrading...
and increasing the production of its sintering plant in 2009, enabling it to increase the proportion of sinter used in its blast furnace from 55 percent to 70 percent.

This is, however, a general rather than universal rule. As Exhibit 8 shows, the prices of lump, pellets, and sinter do not always move the same way. Nor is the cost of iron ore the sole consideration in deciding on burden mix. Other costs also have a bearing.

Environmental concerns led one Asian company to adjust its mix from high-sinter to high-pellet content. It used the high-sinter mix until 1999, when its sintering plant was closed for environmental reasons. As a result of the extra handling and reprocessing costs, sinter became very expensive. Over a two-year period, the company altered the mix from an 80-20 sinter-lump mix to a 70-30 pellets-lump mix. The new formulation will save the company about $5 million in annual operating costs.

Transportation and logistics can also have an effect. Different ores are suitable for different prereduction processes, and changes in the burden mix can lead to changes of source, in turn altering logistics and transportation costs. For instance, Chinese companies have high iron-ore costs even though they generally use high proportions of sinter. This is because of high inland-transportation and freight costs: China imports from as far away as Brazil.

Different burden mixes also have an impact on blast furnace efficiency, affecting productivity, slag formation, and energy and reducing-agent use. All of these considerations and complexities mean that decisions on the correct burden mix will be varied and individual. However, those opportunities are worth exploring, and exploring them should be given the highest priority.

**EAF Charge Composition.** Scrap is the main input for most EAFs worldwide, but supplies are limited and, over the medium term, they are likely to remain tight, particularly in the developing countries where steel production is expanding most rapidly. The lack of high-quality scrap also prevents many EAFs from making high-quality products.
The alternative to scrambling for scrap is to look for substitutes—either pig iron or direct reduced iron (DRI) in the form of hot briquetted iron (HBI). This does have drawbacks. These substitutes are generally more expensive than scrap, and the most straightforward source, the merchant market, has limited liquidity. Trade volume for pig iron is low outside China, while trade in DRI-HBI is also limited, as most capacities are “captive,” producing only for affiliated steel operations. Most production is in India, the Middle East, and Latin America, relying on cheap supplies of gas or coal, but trade is expected to grow with increases in DRI capacity.

Exhibit 9 demonstrates the options. Companies wanting to secure stable supplies can consider producing pig iron or DRI for themselves. This can be expensive in capital terms unless the company has spare capacity, and it works for DRI only where there is access to cheap gas and coal supplies.

Against this are the savings in electricity permitted by hot-charging pig iron and DRI if electricity prices are high. Some steel companies in China have charged an exceptionally high proportion of pig iron when electricity prices are high.

The substitution effect is not the only benefit. Increased use of DRI-HBI or pig iron, up to a certain level (as high as 45 percent, depending on individual cases), enables EAFs to produce flat-rolled and other high-quality steel products that cannot be made with scrap.

If these products can be sold at higher prices than scrap-based items, the additional income can outweigh the extra expense of using DRI-HBI or pig iron. This, though, is possible only if the producer has already acquired some of the extra skills associated with dealing in more liquid markets, for example, having an active sales function that understands the demand market, as well as sophisticated production and sourcing functions and raw-material market intelligence.

If a producer is to realize the full benefits of flexibility in materials, cooperation across a range of functions is essen-
tial. Decision makers must examine the length of the supply chain with the goal of optimizing raw-material sourcing, raw-material utilization in production, and sales of finished products in the field. Flexibility is possible at each stage within the production process in the increasingly liquid markets for raw materials and—given more flexible contracts—with customers for the end products. Preconditions for success also include a continuous information exchange among sales, production, and sourcing; decision-making processes informed by demand; supply and production efficiency; and a focus on profit maximization.

**Capacity Management**

Unpredictable demand creates severe problems for steel companies and makes capacity management a major issue. Traditional business models operated on the assumption of constant production at high-capacity utilization. As a capital-intensive industry, steel has high fixed costs, while inconsistent production results in high operating costs because of increased energy consumption and wear on production facilities. Nor is it easy to rapidly adjust capacity or its utilization: any such changes have technical limits, and putting those changes into effect can take a long time.

When the circumstances underpinning a model change, it is necessary to review it. Capacity management has become an essential element in company strategy.

We see both short-to-medium- and long-term options. In the short-to-medium term, companies have to look at adjusting blast furnace capacity and utilization in response to crises and demand swings, and at adjusting inventories to cope with volatile demand. In the longer term, it makes sense to develop and manage capacity networks to achieve a balance between efficiency and flexibility.

**Blast Furnace Capacity and Utilization.** Worldwide, most steel is produced using the integrated production route. Although it is very effective, it is highly inflexible for volume adjustment.

We found that during the global financial crisis, some furnaces were at unprecedentedly low levels of use. Utilization of one in Germany dropped to 30 percent. Others were temporarily shut down. One global producer shut down more than 40 percent of its European capacity for months. None of these companies would have thought such reductions technically feasible before the downturn. Some turned down furnaces once a week for two days. Such “intermittent shutdowns” formed a middle way, allowing a much more rapid resumption of full production in response to any upturn.

Such responses show that companies have grasped the broad range of possible ways to reduce production. Before making such choices, they do still need to make a full assessment of available options and their financial and operational impacts.

The choice between reduced utilization and extended shutdown is largely a matter of deciding between minimizing operating costs and maintaining capacity for a rapid return to full production in response to an upturn. Shutdown minimizes losses when demand is low but reduces flexibility. It takes around a month to shut down a blast furnace by gradually reducing production, and it takes a further two to three weeks to restart production following an extended shutdown—even if blowers have been kept hot.

The longer demand remains low, or the greater its reduction, the likelier it is that shutdown makes sense. Companies need to project the length and extent of downturns in demand, simulate the financial impact of different measures under different demand projections, and use the results as a key element in decision making.

However, in most situations, the direct financial impact of a shutdown is not significantly different from reducing production of a blast furnace. For a blast furnace in Western Europe with 2 megatons of annual capacity, BCG conducted an outside-in financial simulation based on considerably reduced demand. This assumed that average variable costs of $450 per ton increase with reduced utilization because labor costs remain much the same, and energy and raw-material costs do not decrease proportionately with output. So, for instance, a ton of pig iron produced at 65 percent utilization costs 15 percent more than it would at 100 percent utilization. Shutdown, by contrast, minimizes operating costs because labor costs fall to around 70 percent, and others—apart from the minimal energy expense of keeping blowers hot—are eliminated.
The results for the most likely real-life scenarios indicate that there is no significant difference between the direct financial impact of reduced utilization and shutdown. (See Exhibit 10.)

For example, if demand drops by 20 percent and the crisis lasts four months, reducing utilization by 20 percent for that period would mean a profit of about 52 percent of normal annual profits under full utilization for the 12 months from the start of the crisis. Choosing to shut down the blast furnace for the four months would mean a profit of about 49 percent of normal annual profits. In other words, the profit differential between the options is only about 3 percent of normal annual profits.

Cost projections for blast furnaces are, in any case, only part of the picture. Companies must factor in other elements leading to the wide range of measures taken to reduce production during the global financial crisis. First of all, individual blast furnaces have different technical limits to utilization reduction. Not every operator can reduce utilization to 30 percent. Another key element is the impact on production levels in coking plants, which are even less flexible than blast furnaces. They cannot operate below 70 percent utilization, and hot idling or a shutdown runs the risk of destroying the plant. Any company that has a coking plant has to decide how it will use its excess capacity should its blast furnace be shut down. Decision makers must also consider the impact on the workforce.

Exhibit 10. There Is a Large Bandwidth with Little Difference Between the Outcomes of Reduced Utilization and Shutdown

A 20% demand decline in a four-month crisis: reduced utilization earns more than shutdown by 3% of precrisis profits

Reduced utilization earns less than shutdown by 10% of precrisis profits

Sources: Interviews with industry experts; BCG analysis.

Notes:
- Each curve represents scenarios with the same profit differential for either decreased utilization or shutdown. The financial difference was calculated for a 12-month period from the crisis starting point. The assumptions for a noncrisis scenario were the following: revenues at $600 per ton and costs at $450 per ton of product (iron ore, 50 percent; energy and other raw materials, 55 percent; labor and other, 10 percent; and credits, –15 percent). The assumptions for a crisis scenario were the following: revenues at $400 per ton. Except for iron ore costs and credits per ton staying the same, all costs increase with reduced utilization. For example, at 65 percent utilization, the cost per ton of product is 15 percent higher than that at full utilization; under shutdown, all costs are eliminated except that most labor costs remain, and limited energy costs are incurred to keep blowers hot.

1This refers to shutdown for an extended period (at least one month), which requires one month of advance preparation and three weeks of ramp-up time to resume full utilization after restart.
(which may include highly skilled and hard-to-replace personnel), on external communities such as power stations relying on the byproducts of steel production, on customer relationships, and on their overall market position.

All indications are that closing a blast furnace for an extended period is a decision to be made with extraordinary caution. It demands extreme effort, risks damage to the furnace, and cannot be reversed rapidly. In general, it should be considered only when it is certain that the shutdown will last at least three months.

**Inventories.** If shutting down blast furnaces is essentially a crisis management measure, better inventory management is an effective response to endemic demand volatility.

There are two broad responses to volatile demand. Companies can either vary production levels to match demand, creating inconsistent, expensive production, or they can keep production constant and use safety inventories as a buffer. Using inventories as insurance in this manner is costly, because it demands high levels of stock.

Many companies mix the two strategies, trying to keep an inventory level that balances production and inventory-holding costs. Increasing volatility means, however, keeping larger inventories. Our analysis shows that if, for instance, standard variations in monthly demand increase from 20 percent to 40 percent, a company with a standard cycle time of two months will have to increase its safety inventory from around half the average monthly demand to almost an entire month’s amount just to maintain a service level of 95 percent.

Companies should therefore look at ways to keep safety inventory levels low without risking revenue potential or unnecessarily disrupting production. Options here include customizing service levels for each customer segment, reducing the impact of volatility by standardizing end products, and stocking at an earlier stage to reduce the variety of inventory needed. Furthermore, reducing cycle time through lean production methods is another option, which is discussed below.

**Developing Capacity Networks.** In the longer term, companies should aim to develop integrated networks of capacities, enabling an extended balance between efficiency and flexibility. Given that most companies built and managed capacities with a strong emphasis on efficiency during the boom years before the global financial crisis of 2008, their investment and replacement strategy should now emphasize diversifying capacities by adding more flexible production units.

The ideal network should match different assets with varying emphases on efficiency and flexibility:

- High-efficiency, low-flexibility capacity is assigned as base load, matched with base demand, and kept running at high utilization levels.

- Lower-efficiency, high-flexibility capacity is assigned as peak load, matched with upswing demand, and, hence, utilization is adjusted according to demand.

- Very high upswings too infrequent to justify capital investment should be met by sourcing from external suppliers.

Some companies have moved toward this philosophy, creating “hybrid” networks using large integrated blast furnaces for base demand and more flexible capacity such as shaft furnaces, EAFs, or smaller blast furnaces for upswing demand.

There are, though, limitations on this. Small blast furnaces cost more in capital investment per ton of output than larger ones, and shortages of high-quality raw material for EAFs can limit them to producing only long or low-quality products, preventing their use at peak-load capacity for high-quality output.

Furthermore, fresh investment in more flexible capacities seems to be not very likely in major steel-producing regions. Sluggish demand in the United States and Western Europe means that there is little need for additional capacity, while strong demand growth in China has created a trend toward efficiency and larger blast furnaces that will likely be further accentuated by government pressure for industry consolidation. Short- and medium-term investment in more flexible capacities seems more likely in emerging markets such as the Middle East and India.
The fact, though, remains that companies with a range of integrated capacities are better equipped to adjust production volumes. In a crisis, they have a better ability to shut down capacity—either by sharing capacity across plants or trading among them—without jeopardizing customer relationships or long-term market positions. They also have more choices about what to shut down, and they can fit blast furnace shutdowns to technical specifications or furnace-relining schedules. Smaller companies don’t have these capacities by themselves, but they can enjoy similar flexibility by cooperating with others and optimizing production across networks. A recent announcement from the minimill industry underlines the view that EAF units will gain market share as network flexibility gains higher value.

**Capacity Management.** Companies that have learned how to maximize capacity management have the following abilities:

- They are prepared to react to decreasing demand during crises.
- They can optimize production and inventories to cope with increased volatility during normal times.
- They maintain a long-term vision of balancing capacity within a network.

Capacity management is technically possible and will generate quantifiable impacts. Companies with an adaptive strategy will exploit the flexibility made possible by capacity management.

**Traditional Flexibility Measures**

Traditional measures aim to enhance flexibility by decreasing a company’s fixed-cost base and making it more capable of reacting to demand swings. Typical examples of such measures are resource adaptation and lean management—both already well known within the steel industry and high on company agendas because of their operative and strategic importance.

**Resource Adaptation.** Companies need to adapt to demand swings not only in crises but also in the course of everyday business. This can be done in two ways. The first is by cutting internal resources to the lowest demand level so that all upswings are met by external services. This converts fixed costs to variable costs, increasing flexibility. The second is by shifting resources according to current demand by employing flexibility measures without incorporating external services. This provides a more flexible set of resources capable of following demand swings—swing capacity. In current practice, companies generally mix the two approaches to guarantee maximum flexibility. (See Exhibit 11.)

The HR area is a natural target for this approach because it represents a substantial share of any company’s total costs. The measures available can be mapped on a matrix according to their effectiveness and their impact on employees’ engagement. The size of the bubbles in Exhibit 11 represents the percentage of the companies surveyed that had taken those measures. The matrix shows that, in terms of both effectiveness and employees’ engagement, flexible shifting of resources tends to be more efficacious than outright cutbacks.

**Lean Management.** Lean management, an established concept for identifying and eliminating waste, can be used to gain flexibility and shorten cycle times, allowing for quicker reaction to demand fluctuations. Cycle time reduction also makes more efficient use of resources while keeping output constant and freeing up further capacity. So it is particularly effective in making companies responsive to volatile and unpredictable environments. This freed capacity has another positive effect: it shifts capital expenditures for new production capacity into the future.

Lean management focuses on identifying and eliminating non-value-adding activities—that is, waste. There are seven types of waste: overprocessing, overproduction, transportation, motion, inventory, defects, and waiting.

Waste can be detected by using value stream mapping, a technique that traces the activities of a process, separating value-adding from wasteful activities. Another means of identifying non-value-adding activities is the Muda Walk, which entails a shop floor tour to identify the sources of waste. In steel, waiting and overprocessing are common types of waste.
Once the sources of waste have been identified, lean tools can be applied to eliminate them. Examples relevant to the steel industry include reduction of changeover time, cycle time harmonization, and enhanced maintenance. Their application should reduce cycle time.

For example, the changeover time at a client’s continuous billet caster could be reduced from 55 to 10 minutes, not only significantly increasing end-product flexibility but also reducing cycle time. Another example is the optimization of maintenance, reducing downtime by focusing on different maintenance activities over time.

Finally, standardization enables a sustainable waste-reduction focus and is therefore the main pillar of continuous improvement.

**Imperatives for Steel Executives**

Flexibility is an integral element in an adaptive strategy for steel companies operating in a highly uncertain environment characterized by both increased volatility in raw-material prices and unpredictable demand. As with other elements in an adaptive strategy, it is a matter not of reacting to the new environment but of being able to foresee developments and being at the forefront, exploiting the opportunities they may offer.

Inevitably, there are different levels of readiness in the industry. Exhibit 12 illustrates the ladder of stages—laissez-faire, follower, performer, and industry leader—that companies ascend on their way to flexibility excellence. The degree to which companies implement the outlined flexibility levers will, in our view, determine their competitive position within the industry.

Companies that want to prosper in this demanding—but still potentially profitable and rewarding—environment must face the challenges. Executives must answer some difficult questions that can help them clarify which capabilities they already possess and which they need to build up.

**Flexibility Through Optimized Material Use:**

◊ Is our organization aware and prepared for increasingly liquid markets and shorter-term contracts?
Do we have the raw-material and end-product market intelligence in place to identify market opportunities?

Have we developed the capabilities within our company to understand and explore the technical flexibility and limits of raw-material use in each of the major production processes?

Do we encourage exploration of cost-saving opportunities by varying raw-material use through incentives to reduce total cost of output?

**Flexibility Through Capacity Management:**

Have we developed the capabilities to economically reduce utilization or even shut down production during another crisis?

Do we have the capabilities to balance production and inventory management to meet the challenges of increasing demand unpredictability in a normal economic environment?

Do we have an action plan to optimize our whole network—considering concepts such as interchangeability of integrated and EAF routes and smaller production units—in light of the need for balancing base- and peak-load demands?

Do we regard collaboration with competitors as a possibility for optimizing production across an intercompany capacity network?

**Flexibility Through Traditional Measures:**

How do we adapt our company’s resources to demand fluctuations? To what extent do we employ or combine cutback and flexibility measures?

Do we apply lean methods to identify and eliminate waste in order to reduce cycle time?

As for identification of waste, do we apply value stream mapping or perform Muda Walks on a regular basis?

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**Exhibit 12. The Application of Flexibility Measures Determines the Level of Industry Excellence**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laissez-faire</td>
<td>1</td>
<td>Industry leader 4</td>
</tr>
<tr>
<td>Follower</td>
<td>2</td>
<td>Performer 3</td>
</tr>
</tbody>
</table>

- **Flexibility of Input and Output Materials**
  - Ability to quantify the impact of changing the burden mix
  - Optimization of the supply chain on the basis of sourcing and sales
  - Full trading capacity

- **Capacity Management**
  - Optimization of inventory management
  - Knowledge of shutting down a blast furnace or running it economically at decreased utilization
  - Optimization of the production network

- **Other Flexibility Measures**
  - Cutback and subsequent use of external services
  - Application of lean techniques in the production facility
  - Flexible shifting of resources

Source: BCG analysis.

---
In today’s fast-changing world, almost every company in the steel industry is a niche operator. This situation is driven by the industry’s high degree of fragmentation. In 2009, a full 38 percent of the global output of crude steel was produced by companies that themselves accounted for 1 percent or less of the whole. China produced 46 percent. The largest single producer, ArcelorMittal, accounted for 6 percent, and together, the five companies next on the list accounted for only 10 percent.

Lacking the protection provided by superior scale, niche operators are always vulnerable to new entrants in their markets. Maintenance of competitive differentiation is all, which means companies stay ahead of the game played by current and potential competitors by providing something that differentiates them from the rest.

We see two types of niche companies: regional niche operators and producers of specialized, nonstandard steel. The regional niche operators rely on maintaining high market shares in localized markets, building on a competitive edge supplied by an advantage in transportation costs and strong customer relations.

While the nature of steel production means that every company mixes high- and low-grade output, producers of specialized, nonstandard steel rely heavily on their proprietary products. This means that although they generate smaller outputs than the big, diversified steel producers, they are able to charge higher prices and serve worldwide markets.

Both types are vulnerable to new entrants in their markets, whether they undercut them on price or provide better versions of the same products. Their common problem also has a common solution: to innovate quickly and continuously to stay ahead of the competition while profiting from rising opportunities.

Steel companies must, therefore, prioritize R&D, the source of innovations. This is always subject to available resources, but the mere act of spending more money on R&D than others do will not bring the necessary solutions.

Companies need to understand their current position within the industry, as well as their future options, in order to align their R&D focus, organization, and processes with their innovation strategy. That innovation matters more than ever is clearly understood. A recent BCG survey of manufacturing and industrial companies, conducted for Bloomberg Businessweek, showed that 74 percent saw innovation as a top-three priority. This emphasis has been strengthened by the economic downturn, with 48 percent rating innovation important and 40 percent rating it extremely important in securing a recovery.

Current practice does not, though, match aspiration. Less than half (48 percent) of respondents from manufacturing were satisfied with innovation performance in their own company. A strong element in dissatisfaction is the feeling that it is hard to establish outcomes for innovation: only 36 percent were satisfied with current innovation-measurement practices.

R&D in Steel

Steel’s investment in R&D as a percentage of revenue is much lower than that of other industrial sectors. Steel executives have argued that this is because of the high resource intensity and the industry’s resulting low value
added. Furthermore, steel is a well-established, mature industry whose history stretches back two centuries. Yet these are only partial explanations. As Exhibit 13 demonstrates, when R&D spending is compared with gross value added, the gap narrows proportionally, but steel continues to trail other sectors—by huge margins when the comparison is with the electronics or automotive industry.

Although industry spending on R&D is low, the pattern is uneven, with some companies spending more than others. Spending more does not, however, as Exhibit 13 also demonstrates, lead automatically to superior margins. There is, at first glance, little correlation between R&D expenditure and profitability.

This raises the question of what defines successful R&D in steel. To find an answer, we have to look into the current state of R&D in the sector. BCG analysis shows that the industry can be clustered into three distinct types of producers. (See Exhibit 14.)

- Specialized steel producers focus on nonstandard high-margin proprietary products, and they are generally smaller in size and operate specialized and complex equipment designed particularly for the manufacture of their products.
- Diversified steel producers focus on selling a broad mix of standard steel grades, as well as a significant share of specialized products such as high-value steel sheet for the automotive industry.
- Mass producers and me-too companies focus on their cost position, requiring high output and corresponding economies of scale and producing mostly standard steel grades, or commodities.

A deeper look into the company categories reveals some correlation, with a broadly linear relationship emerging between revenue and R&D for diversified steel producers. The bigger companies spend more in absolute terms, but this does not make them more profitable. Analysis of a sample of diversified producers shows, paralleling Exhibit 13, no discernible relationship between absolute spending on R&D and earnings before interest and taxes.

All of which serves to reinforce the lesson that simply spending more on R&D will not be enough to produce re-
Developing a Strategy

The first challenge is to decide what you want R&D to do for your company. Innovation can support two basic strategic purposes: improving profitability and fueling growth. It can be focused on a variety of different outputs: processes, products, applications, and steel-related services.

Having decided on its innovation targets—for example, investing in process innovation to reduce CO₂ emissions—a company must determine how it is going to move forward. For each process, product, application, or service category there is a choice of possible implementation strategies. (See Exhibit 15.) The company needs to decide whether its goal is to be a first mover (being the first to market with a new and innovative product), a fast follower (rapidly imitating and improving the first mover’s innovation), or a late follower (adopting only those innovations that show themselves to be sustainable successes).

Each position has its advantages and built-in handicaps. Some innovations, particularly far-reaching process advances, demand resources available only to large companies or consortia. Small companies are better off trying to be second best. Followers enjoy the advantage of avoiding costly development, but if everybody is a fast follower, the pace of innovation within an industry as a whole drops significantly.

Industry experts confirm that—as being a first mover is no longer a precondition of success—implementation is central to strategy discussion in steel companies. Deciding in which categories a company wants to lead or follow is a detailed portfolio decision for each innovation object.

Where a company focuses its R&D reflects its current position within the industry. BCG mapped patterns of patent filings from 2005 through 2010 for each industry group—specialist, diversified, and me-too producers. Patent filings tell only part of the innovation story because not all inventions are innovations, not all innovations are filed as patents, and sometimes, companies avoid filing patents in order to avoid the publication of proprietary knowledge. However, mapping the patents across the in-

Sources: BCG ValueScience Dataportal; Bloomberg; company reports; BCG analysis.

1Average revenue, 2007–2009.
Industry gives a good picture of the areas of current focus. (See Exhibit 16.)

Industry clusters show a pattern one might reasonably predict. The me-too companies are heavily focused on process and securing profitability, while the specialist and diversified enterprises are equally weighted toward applications, products, and generating growth.

These trends are not, however, carved in stone. Companies need to be aware that patterns in the industry are changing, with new entrants threatening existing operators and some established companies seeking to change their own profiles.

The past few years have seen diversified and specialist producers filing fewer patents while the me-too operators file more. (See Exhibit 17.) In 2005, the average specialist producer filed more than eight times as many patents as a me-too. By 2009, the lines had converged, and they may soon cross.

This reflects the me-too producers’ strategy of seeking to broaden their business reach by selective use of R&D to challenge specialist and diversified producers in their established niches. The specialists, in turn, have been filing fewer patents because those niches are already well developed. Their options include adding more niches to become multiniche participants. BCG analysis of applications-related patent filings shows that around 15 percent of those from specialist companies relate to alternative energy, a new and potentially highly important sector.

An alternative is to expand into the business areas of the diversified producers. They are, though, at risk: although large companies have the resources to watch trends and developments across the entire industry, small companies may lack the resources and capabilities to see everything and, accordingly, might miss a trend.

### R&D and Patents

One potential indicator of the effectiveness of a company’s innovation effort is the extent to which it files patent applications, and BCG analysis of the industry on this basis appears to indicate a considerable variety of behavior in this respect. Our findings covered 37 companies across

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**Exhibit 15. An Effective Innovation Strategy Needs to Be Detailed for Each Innovation Object**

<table>
<thead>
<tr>
<th>What</th>
<th>Profitability</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost</td>
<td>Price</td>
</tr>
<tr>
<td>Steel-related services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Combining the what and the how …**

**… leads to strategic decisions for each object**

| Steel-related services |
| Applications |
| Products |

| Processes |

*Source: BCG analysis.*

---

Combining the what and the how … leads to strategic decisions for each object.

<table>
<thead>
<tr>
<th>Profitability</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Price</td>
</tr>
<tr>
<td>Steel-related services</td>
<td></td>
</tr>
<tr>
<td>Applications</td>
<td></td>
</tr>
<tr>
<td>Products</td>
<td></td>
</tr>
<tr>
<td>Processes</td>
<td></td>
</tr>
</tbody>
</table>

| First mover |
| Fast follower |
| Industry |
| Late follower |

**Source:** BCG analysis.
Exhibit 16: Industry Clusters Drive the Choice of R&D Focus Areas

Example patent map: specialist steel producers

Focus areas of industry clusters

<table>
<thead>
<tr>
<th>Profitability</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Price</td>
</tr>
<tr>
<td>Services</td>
<td>Applications</td>
</tr>
<tr>
<td>Product</td>
<td>47%</td>
</tr>
<tr>
<td>Processes</td>
<td>10%</td>
</tr>
<tr>
<td>Applications</td>
<td>Usually not patented</td>
</tr>
<tr>
<td>Products</td>
<td>40%</td>
</tr>
<tr>
<td>Processes</td>
<td>10%</td>
</tr>
<tr>
<td>Services</td>
<td>Usually not patented</td>
</tr>
<tr>
<td>Products</td>
<td>15%</td>
</tr>
<tr>
<td>Processes</td>
<td>85%</td>
</tr>
</tbody>
</table>

Sources: THEMESCAPE; Thomson Innovation; BCG analysis.
Note: The figures enclosed in boxes indicate the number of patents filed, 2005–2010.

Exhibit 17. Me-Too Companies Are Clearly Improving Their Innovation Position

Change of patent-filing behavior...

...generates dynamics—especially for me-too companies

Revenue ($millions)

<table>
<thead>
<tr>
<th>Diversified steel producers</th>
<th>Me-too players</th>
</tr>
</thead>
<tbody>
<tr>
<td>... and mass producers</td>
<td>They do selective innovation to expand business reach</td>
</tr>
<tr>
<td>Diversified steel producers</td>
<td>They broaden their portfolios or become multiniche players</td>
</tr>
<tr>
<td>Specialists</td>
<td></td>
</tr>
</tbody>
</table>

Sources: THEMESCAPE; Thomson Innovation; BCG analysis.
Note: CAGR = compound annual growth rate.
the globe that, in 2008, accounted for 430 million tons of crude-steel production, 34 percent of the worldwide total.

Some companies do not file patent applications for all of their innovations. Our discussions with industry insiders point to a number of possible explanations for this.

They may wish to avoid disclosing information, or they may regard the filing process as too expensive. Nor do incremental product changes require the filing of new patents. There are also companies whose balance-sheet declaration of R&D spending may not encompass the whole of their R&D effort.

Given these provisos, it is still possible to draw some broad conclusions about their R&D efforts. One is that although established companies in developed Asia and Europe are above-average spenders, high R&D expenditures do not guarantee high patent output.

It is possible to divide these companies into four broad groups. Exhibit 18 shows—in the top right-hand quadrant—a clear grouping of companies that have a strong R&D focus reflected in both spending and innovation, and another at the bottom left that competes on cost advantage rather than innovation. This has to be qualified with the usual disclaimer about incomplete information. It may be that the companies that appear to derive a lot of patents from limited spending are not declaring their entire R&D expenditure under that heading. Likewise, those at the bottom right that apparently are getting very little from a high expenditure may be choosing, for the reasons listed above, to avoid the patent route.

Furthermore, this analysis of resource commitment and the number of patents filed, together with a detailed patent map, can help steel companies get a very good understanding of their competitors. This could be an additional data point in a structured analysis of the competitive landscape.


<table>
<thead>
<tr>
<th>Resource commitment (R&amp;D spending as a percentage of revenue)(^3)</th>
<th>R&amp;D output (number of patents filed)(^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

It may be that the companies that appear to derive a lot of patents from limited spending are not declaring their entire R&D expenditure under that heading. Likewise, those at the bottom right that apparently are getting very little from a high expenditure may be choosing, for the reasons listed above, to avoid the patent route.

Furthermore, this analysis of resource commitment and the number of patents filed, together with a detailed patent map, can help steel companies get a very good understanding of their competitors. This could be an additional data point in a structured analysis of the competitive landscape.


<table>
<thead>
<tr>
<th>Cumulative R&amp;D spending, 2007–2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
</tr>
<tr>
<td>Japan</td>
</tr>
<tr>
<td>India</td>
</tr>
<tr>
<td>China</td>
</tr>
<tr>
<td>Russia</td>
</tr>
<tr>
<td>South America</td>
</tr>
<tr>
<td>Other Asia-Pacific</td>
</tr>
<tr>
<td>United States</td>
</tr>
</tbody>
</table>

*Exhibit 18. Industry Analysis Shows Different Patent-Filing Behavior and Resource Commitment*

Sources: BCG ValueScience Dataportal; Bloomberg; company reports; Thomson Innovation; Themescape; BCG analysis.

Note: Logarithmic scale. The benchmark includes 37 companies representing 34 percent (453 million tons) of crude-steel production in 2008.

\(^1\)Total, 2005–2010.

Steel producers are making distinct strategic choices that are reflected in their position on the matrix in Exhibit 18. What all producers in all the quadrants have in common, however, is the opportunity to improve the efficiency of their innovation initiatives by improving their R&D operations in terms of both processes and organization.

**Achieving the Optimal R&D Setup**

Our studies of the steel industry show that there is a wide range of approaches to R&D processes and organization. Some companies have very formalized structures that include dedicated R&D centers of competence for individual product lines and applications. Others are much more fragmented, with experts carrying out R&D alongside their daily routines.

We have also found that a company can achieve efficiency and excellence no matter which industry cluster it operates in or what its innovation strategy is. It is a matter of aligning processes and ensuring that the R&D process is organized for maximum effectiveness.

BCG has helped companies in a wide range of industries transform their R&D operations, in terms of both processes and organization.

For example, BCG worked with a consumer electronics conglomerate handicapped by a slow and expensive development process. We helped the company devise a four-step innovation process that used defined milestones and timelines, with activities defined by flow diagrams and detailed descriptions of activities and output requirements. The new approach reduced both the time and cost of the company’s development process by 50 percent.

Similarly, working with a European supplier to the automotive industry, we assisted in changing the R&D culture. Previously, the company had made long-term investments in comparatively few projects because resources were trapped in unprofitable projects that had been allowed to run unchecked. The culture of the company interpreted the discontinuation of a project as a failure, with consequent effects on motivation and careers.

We helped implement a new structure in which many more projects are initiated, drawn from a wider range of sources. Projects go through the filtering process provided by four “stage gates” and selection criteria, which are simple and transparent. Unproductive projects are halted at an early stage, avoiding expensive investment in nonrunners, and because early assessment is built into the process, there is less fear of failure, and the greater number of starters means that ultimately more ideas make it to the end of the process.

In another example, the R&D function of a chemical company was reorganized by separating research from development to make innovation more responsive to the market. The previous structure created silo thinking, with strategic business units having little effect on technology platforms: product development focused on incremental product changes that were based on customer requests rather than on breakthrough innovations, interchange between different product-development groups was limited, and there was little relationship between the strategic business units and research platforms.

The new structure has a much stronger market orientation. Development at that company now focuses on identifying market opportunities and requests, and research is funded by the business units. An innovation manager acts as customer for the technology platforms while product development managers ensure market orientation of innovation projects. The whole system is monitored by a commercial head and has its strategy defined by a body of innovation managers working across the strategic units.

Another example is provided by steel’s involvement with the fast-growing offshore-wind-power industry. Exhibit 19 illustrates how companies can seek new sources of demand and use innovation to serve those demands. The wind power market has become significant, and its distinctive, fast-evolving needs are driving innovation in steel companies.

This type of innovation has fulfilled demands for new products, applications, and steel services. New products have been designed to meet strength and endurance requirements, while design innovation has reduced the weight—and therefore the cost—of towers. Forward inte-
Flexibility and Innovation

Innovation has allowed the development of services, such as helping companies that assemble monopiles and jackets make effective use of the steel and developing special edge beveling that is required by downstream customers. Such forward integration and cooperation with downstream customers can give companies first-mover advantages and ensure direct and efficient knowledge transfer.

This particular example further underpins the importance of looking into new industries and searching for new trends. It shows how innovation helps find new markets and applications for steel.

### Imperatives for Steel Executives

Decision makers at steel companies can learn a series of lessons that they can put into practice as they respond to the demands of the modern market. Each company needs to identify its R&D focus areas, deciding for each innovation object (be it a product, process, application, or service innovation) whether to be a first mover, fast follower, or late follower. Furthermore, the company needs to evaluate its R&D organization and processes. Do they fit the requirements of the innovation strategy? Exhibit 20 shows the stages through which a company can develop as it strives for excellence in R&D, each progression entailing particular changes to both processes and organization. Regardless of industry cluster or innovation strategy, companies can generally improve their R&D setup by aligning their processes and organization.

Executives in the steel industry must answer some difficult questions that can help them clarify their company’s approach to innovation.

**Innovation Aspects of the Steel Industry:**

- Do we benchmark our R&D spending relative to our competitors and other industries?
Do we understand the spending schemes and rationale of our competitors?

Can we quantify the effect of our R&D efforts on profitability (de-averaged by product, process, application, and service)?

Alignment of Innovation and Business Strategy:

Do we address the full spectrum of innovation areas in the steel industry (products, processes, applications, and steel-related services) or do we focus on specific areas depending on our business strategy?

Within each innovation area, do we proactively choose our strategy (first mover, fast follower, or late follower)?

What are the current requirements of our customers with regard to product characteristics and service needs?

Do we know how to benefit from global trends affecting our niches (such as CO\textsubscript{2} regulation, electric vehicles, and global mobility)?

What products do we need to develop in order to cater to future customer requirements and newly emerging sectors or product applications?

Which existing products might be substituted by other materials or superior steel grades?

What are possible new market entrants (competitors, customers, and suppliers) and how could they affect our business?

Internal Capabilities:

Do we have the processes and capabilities to scan the market, react to changes, and internalize the benefit?

Will our organization setup allow us to execute and control the processes needed for effective R&D?

From our perspective, answering these questions is essential for all steel executives. Succeeding in dynamic markets means adapting to a continuously changing environment. R&D will play a crucial role in your ability to face these challenges, and you can define your company’s innovation strategy.

Exhibit 20. Alignment of Processes and Organization with Innovation Strategy Determines Level of R&D Excellence

Source: BCG analysis.
The adoption of an adaptive strategy is essential if steel companies are to adjust to an increasingly uncertain environment. A once rather predictable world is now defined by volatility in raw-material prices and demand for products, as well as the shift of consumption and production to emerging countries, especially China.

An effective strategy should anticipate, rather than simply react to, change and opportunity. Companies need to become fully aware of all aspects of their environment—from raw-material price movements to the new self-sufficiencies of developing markets. We believe that becoming more flexible and choosing the right R&D focus and setup will enable steel companies to thrive.

Executives must ask themselves whether or not their company has the requisite capabilities. And if not, how they should go about developing them:

- Is our market intelligence sensitive enough to pick up all trends and movements, for example, from raw-material swings to end-market movements and industry trends?
- Is our productive capacity flexible enough to ride shifts in demand and adjust to a broad range of input materials?
- Is our R&D fully aligned—in terms of priorities, organization, and measurement of output—with overall business strategy?
The Boston Consulting Group publishes other reports and articles related to the metals and mining industry that may be of interest to senior executives. Some recent examples are listed here.

Creating People Advantage 2010: How Companies Can Adapt Their HR Practices for Volatile Times
A report by The Boston Consulting Group and the World Federation of People Management Associations, September 2010

New Bases of Competitive Advantage: The Adaptive Imperative
BCG Perspectives, October 2009

Sustainable Steelmaking: Meeting Today’s Challenges, Forging Tomorrow’s Solutions
BCG White Paper, July 2009

Beyond the Boom: The Outlook for Global Steel
A report by The Boston Consulting Group, February 2007
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