McKinsey & Company

Global Energy & Materials Practice

The mine-to-market value chain: A hidden gem

Enhancing end-to-end performance of the mine-to-market value chain can be a major source of value creation—yet fragmented responsibilities often cause companies to lose sight of the big picture.

This article was a collaborative effort by Stephan Görner, Gregory Kudar, Lapo Mori, Sebastian Reiter, and Robert Samek, representing views from McKinsey's Global Energy & Materials Practice.

October 2020

The mining value chain—which includes everything from extracting raw material to delivering products to customers—is the backbone of the industry. Companies that manage their value chain well can establish a significant source of competitive advantage and value creation. By contrast, those that neglect their value chain are likely to encounter bottlenecks and constraints that will limit shipped throughput and risk yield.

To begin, it is critical to distinguish between supply chains, which manage inbound and outbound logistics and warehousing, and value chains, which are made up of integrated end-to-end processes. Historically, comprehensive management of the latter has not been a priority for mining companies. This oversight has resulted in siloed operations (logistics and commercial services) and organizational setups in which responsibilities are distributed to optimize individual steps (mining, processing, rail, or shipping), rather than a comprehensive whole.

Mining value chains also face pressure from recent shifts in commodity markets (strong price fluctuations, shrinking value pools, changing market structures with new entrants, and tightened regulations) as well as from the ongoing uncertainty of the COVID-19 pandemic.[1] At the same time, environmental concerns continue to evolve, and new regulatory policies continue to be enacted. Companies face unprecedented pressure to increase resilience, flexibility, and productivity to remain competitive.

While preparing to address these tighter regulations, mining companies must significantly reduce their environmental footprint to satisfy the increasing push for disclosure by governments, investors, and stakeholders.[2] Thus, taking a closer look at the value chain from mine to market is the first step in addressing these challenges. In this article, we illustrate how creating transparency to improve decision making and keeping the right tools at hand can help mining companies prepare for an increasingly volatile future. Those that assess their priorities can strengthen their position in the current down cycle and expand their market position in the long term. This is a particularly relevant topic for the mining industry, as recent research shows there is still room for improvement in mining supply chains.[3]

Securing end-to-end efficiency of complex mining value chains

Mining value chains are highly complicated and must account for all assets, including equipment (for example, trucks and shovels), processing plants, and railway and port operations (Exhibit 1). Further complicating matters, the wide range of related activities requires a series of interdependent steps before products reach customers, many of whom live in other countries or on other continents (see sidebar "From extraction to the customer: The mine-to-market value chain").

To date, the mine-to-market value chain has often been handled within organizational silos, which have limited coordination and real-time data exchange. Understanding the mining value chain as a single integrated process, however, can allow companies to take a truly comprehensive view of performance.

Mine-to-market performance enhancements aim to unlock greater potential than optimizing operations, the value chain, or commercial services independently. Our research, which includes mining companies across countries and product types, suggests that mine-to-market optimization

[1] For more on the impact of COVID-19 on materials, see Gauthier Canart, Henrique Ceotto, and Alexander Klimchuk, "Mining companies' response to coronavirus," May 26, 2020, McKinsey.com.
[2] For more on sustainability, see Lindsay Delevingne, Will Glazener, Liesbet Grégoir, and Kimberly Henderson, "Climate risk and decarbonization: What every mining CEO needs to know," January 28, 2020, McKinsey.com.
[3] For more on our recent research on supply chains, see Knut Alicke, Richa Gupta, and Vera Trautwein, "Resetting supply chains for the next normal," July 21, 2020, McKinsey.com.

Exhibit 1

The mine-to-market value chain comprises interdependent steps and corresponding activities.

Value-chain step	Mine	Processing plant	Inventory	Rail	Port	Ship	Market
Activity	Extracting materials (eg, with shovels, excavators)	Processing the raw materials	Managing inventory levels and quality	Moving materials to the port	Stockpiling, loading, and managing vessels	Shipping materials to destination	Delivering the materials to the customer

can generate a 10 to 15 percent increase in earnings before interest, taxes, depreciation, and amortization (EBITDA) by optimizing throughput, product margins, and operating costs. Based on these findings, we identified 11 levers for performance enhancement along the value chain (Exhibit 2). These levers can be addressed either individually or comprehensively but are always interconnected with and build upon data from key value-chain steps (see sidebar "Mine-to-market performance-enhancement levers").

Enhancing a mine-to-market performance relies on two underlying factors: 1) organizational enablement and 2) data and tech architecture.

Organizational enablement encompasses the operating model with restructured business units and a dedicated cross-functional team to dissolve silos and equip employees with the skills, especially around advancing technologies, they need to excel. It includes a mindset shift—perceiving the mining value chain as one integrated process rather than a series of individual steps. Finally, it introduces lean and agile processes as well as continuous improvements in technology and advanced analytics.[4]

Data and tech architecture refers to the infrastructure and pipelines to capture, track, and clean operational data across the value chain; IT

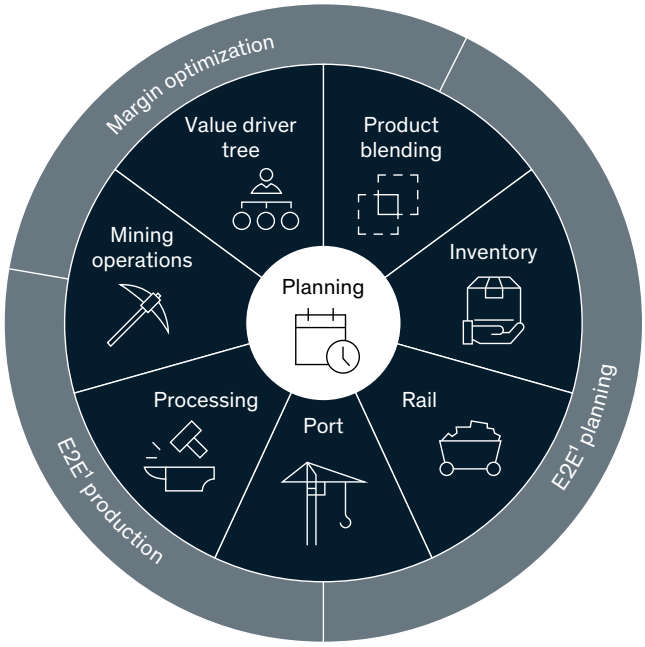
[4] For more on technology-enabled transformations in mining, see "Behind the mining productivity upswing: Technology-enabled transformation," September 25, 2019, McKinsey.com.

From extraction to the customer: The mine-to-market value chain

Raw material is extracted from both open-pit and underground mines with the help of specialized equipment. The material is then transported (typically on conveyors or trucks) to a processing plant, where it undergoes multiple steps to create a shippable product. These steps vary with the respective raw material—for example, ore processing consists of crushing and grinding. For bulk material (e.g. iron ore) once reconditioned, the product is stacked in stockyards and then it is transported to the port. For product types that come in various grades of quality, such as iron ore, an additional step known as product blending takes place before the product is loaded onto the ship and transported to the customer.

Exhibit 2

Mine-to-market performance-enhancement levers can be addressed either individually or as a whole.



[1]End to end.

systems that facilitate integration and continuous evolution of the technology environment; and advanced-analytics models that support decision making.[5] Some mining companies have embarked on their digitization journeys, but there is still room for improvement. The challenge is to orchestrate business decisions across the entire value chain to maximize the impact of the data. End-to-end transparency and data-driven innovations can define the ultimate competitive edge, offer the potential to operate with more agility, increase control, and unlock adjacent value pools.

How to prepare for an increasingly volatile future

A comprehensive mine-to-market perspective can help companies detect and resolve bottlenecks and subsequently optimize all steps along the value chain. Two direct actions can help provide solutions to the mining industry's strategic challenges.

Create transparency to improve decision making in times of uncertainty

In an increasingly complex and volatile world, mining executives are required to make decisions rapidly—even in times of uncertainty. A transparent perspective of the entire value chain can ensure the continuous incorporation and use of all available data to efficiently steer the business. Thus, the changing business environment requires a comprehensive end-to-end evaluation of real-time data to significantly minimize the risk of unintentional and adverse effects on certain parts of the business by solving issues on the other end of the overall value chain. For example, a mine-

[5] For more on building data platforms, see Adrian Booth, Jeff Hart, and Stuart Sim, "Building a great data platform," August 1, 2018, McKinsey.com.

to-market view allows companies to simulate the impact of a set of commodity prices and optimize the value chain to maximize margins for the different price scenarios.

Transparency also allows mining companies to better comply with tightening environmental regulations around the traceability of supply chains and integrated environmental reporting. This means the mine-to-market perspective can enable executives to better understand the susceptibility of their businesses to climate change by simulating the impact of extreme weather phenomena, temporary regional value-chain breakdowns, and rising carbon prices. Thus, a mine-to-market view is critical to successfully address an increasingly volatile and uncertain business environment in the mining industry and has an impact beyond mere operational excellence.

The first step to establishing transparency along the value chain is to build a value-driver tree that represents underlying value drivers across operations, logistics, and sales. The value-driver tree provides clarity about shipped throughput, potential margins, and cost levers to sustain long-term profitability, though it often does not show the complexity of the business (Exhibit 3). In this sense,

Mine-to-market performance-enhancement levers

Eleven core levers factor into mine-to-market performance enhancement.

Value-driver tree: Representation that links business value to a comprehensive set of detailed value drivers, allowing for a better understanding of the business.

Overarching levers

Planning: Improvements such as short- and medium-term planning for port, rail, and mine production through an integrated value-chain optimization model.

End-to-end planning: Performance enhancement of medium- and long-term planning across mines, rail, and ports to solve for a "network optimum" and define optimal value-chain capacity and production requirements.

End-to-end production: Improved performance on production costs across all steps, including mine operations (drilling and blasting and haul cycle), processing (raw material blending), and inventory.

Margin optimization: Enhancement of product mixes and customer contracts to maximize the margin based on the trade-off between incremental products and associated value-chain costs.

Individual levers

Mining operations: Application of data-driven planning of production steps, including drilling and blasting procedures and haul cycle times, as well as regular reviews of the evolving life of the mine plan.

Processing: Improvement of individual processing steps, such as blending raw materials, to maximize yield and throughput, as well as adjustments to capacity and throughput as determined by market demand.

Inventory: Reduction in variability of value-chain bottlenecks (for example, rail and port) and resulting negative cost and customer outcomes through improved stockpile management that determines optimal volumes and locations along the value chain.

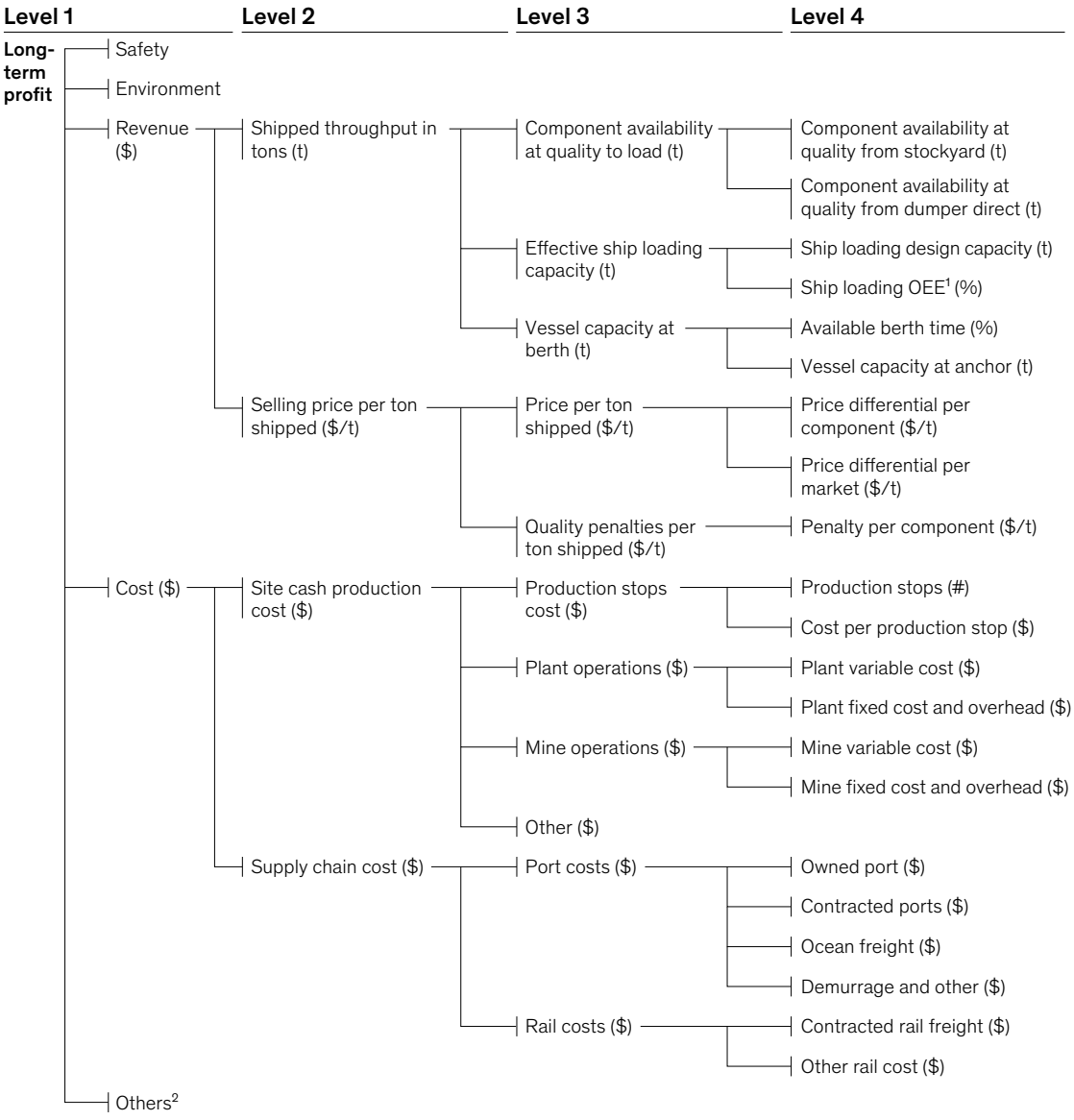
Rail: Streamlined rail logistics, such as scheduling, train configuration, and reverse logistics, to minimize mine-to-ship transportation time and port-stocking costs.

Product blending: Optimization of product blending across the full range of product specifications, increasing blending flexibility to meet customer demand and maximize margins.

Port: Streamlined port logistics (vessel scheduling, product blending, and yard management) to ensure timely loading within assigned windows, avoiding penalties and demurrage and improving throughput.

Exhibit 3

An illustrative value-driver tree is a simple way to display the business.



[1] Overall equipment effectiveness.
[2] Includes soft factors, eg, customer satisfaction, customer diversification, and risk management.

it can be seen as a static model with historical data reflecting interconnected variables, assumptions, and business constraints that offer further insights and help identify problems in significantly less time than in today's operations.

Keep the right tools at hand

Depending on the underlying problem, either a simulation or optimization can be employed. While simulation and optimization are quite different in nature, they are most effective when applied together, which can ensure individually optimized operations with key performance indicators (KPIs).

Simulations rely on "digital twins" of the mine-to-market model to identify variabilities across the value chain. They can also enable throughput diagnostics, bottleneck identification, and scenarios screening for both expected events and uncontrollable factors. A typical performance question is, "How can a company increase annual throughput from 160 to 200 kilotons?" Simulation can also provide insights into current bottlenecks and help determine where to focus. In addition, this approach is well suited to validate and prioritize potential improvement measures based on end-to-end throughput impact and to assess different scenarios for market prices or other uncontrollable factors, including the influence of weather or equipment breakdowns. The basis for understanding interdependences and their implications, such as financial models, are rooted in value-driver trees.

An optimization, however, aims to improve the performance of one step or multiple steps in the end-to-end value chain. Doing so requires running basic analyses to solve for specific objectives—in other words, focusing on one step to optimize the entire chain. For example, if a specific blending strategy doesn't produce the desired results, optimization can help develop potential measures and adjustments to improve its performance. This can be done by making certain assumptions and establishing a clearly defined optimization objective, such as maximized throughput or minimized inventory stock levels. In addition, optimization supports strategic decision making for mine plans and value-chain capabilities to ensure long-term value creation by shifting bottlenecks across units or functions. It can also help to proactively identify areas of focus to drive further process improvements.

Getting started: Assess which area should be a priority

Today's complex mining value chains are almost inevitably subject to disruption. In recent years, however, the stakes seem to have risen as geopolitical uncertainty intensifies and high-cost natural disasters occur more frequently. An integrated mine-to-market perspective can help create further resilience and maximize shipped throughput in the face of disruption. Determining which weaknesses a mining company must address first, however, depends on the specific needs of its value chain. Nevertheless, a few key areas are critical for mining operations and hence represent a promising initial approach for a mine-to-market analysis.

To begin, understanding the value chain's constraints is critical to planning operations. For instance, one company's mine-to-market strategy might lie in the simulation of the value chain to identify and understand how constraints move over time. For miners with comparable assets as parts of different value chains, such insights can enable the transfer of cross-asset knowledge by understanding how and why potential bottlenecks have developed in certain scenarios.

Equally important is understanding how the optimal value-chain setup looks in times of uncertainty. Variability simulations can be based on current throughput as well as future throughput targets. For miners with comparable assets as parts of different value chains, such an analysis

could help determine which end-to-end system is capable of accommodating short- or mid-term production increases.

Value-chain constraints are often the result of unoptimized and disconnected scheduling. Thus, a mine-to-market performance enhancement can help determine the optimal way to schedule capacity from end to end to minimize costly inefficiencies from operational slowdown, potential penalties, or avoidable expenditures.

While margins in mining are typically improved by dissolving bottlenecks across the value chain—thereby reducing costs—they can also be addressed by choosing a production strategy that is closely tailored to customer demands and informed by real-time commodity prices. In a mine-to-market view, a value-maximizing production strategy and its implementation can be determined simultaneously.

Finally, the recent COVID-19 pandemic has shown how disruptive events—both global health crises and natural disasters—can put supply chains at significant risk. With this in mind, a mine-to-market view allows companies to understand the risk exposure of individual mining supply chains across different geographies and take the necessary precautions.

As digital technologies help remove the barriers to entry and tip the scales of competitive advantage, mining executives will need to ensure their organizations rely on a sustainable business model by proactively envisioning and shaping that model's role in an integrated end-to-end ecosystem.

The journey toward an integrated end-to-end mining value chain is complex, but it is also an essential shift to unlocking an untapped source of value. Mining companies must develop a comprehensive mine-to-market perspective to survive down cycles in the short term and strengthen and expand market position in the longer term.

Stephan Görner is a senior partner in McKinsey's Sydney office, **Gregory Kudar** is a senior partner in the Calgary office, **Lapo Mori** is a partner in the Denver office, **Sebastian Reiter** is an associate partner in the Munich office, and **Robert Samek** is a senior partner in the Toronto office.

The authors wish to thank Annouck Driesen, Eddie Elizondo, Jacob Goranson, Alexander Grausam, Álvaro Hernández Nogales, Markus Hofmeister, and Manuel Ross for their contributions to this article.