Mining *for* Value

Industry leaders disclose lessons learned from the supercycle

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Cesco, Center for Copper and Mining Studies, is an independent, plural and not-for-profit organization, based in Chile. Established in 1984 as an association of professionals, it promotes social legitimacy and sound public policies in the mining industry in countries where mining is a strategic industry for their development. It monitors, provides information and quality analysis in novel formats and supports and promotes activities to foster dialogue among members of the mining industry and civil society. Its main public events are Cesco Week in Santiago and Asia Copper Week in Shanghai.

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Foreword

The genesis of this book

In 2015, when the mining industry and most copper exporting countries were suffering the repercussions of the end of the supercycle, the two of us began talking about what had made the end of this cycle especially harsh.

The obvious explanation was the sharp drop in metal prices, but this was not enough to explain the critical condition of the industry and several of its leading companies. Even though the cycle that had started in the early 2000s was probably unparalleled in its speed, length and intensity, there had to be other factors to account for the industry's troubles. After all, managing cyclical markets is an inherent and fundamental aspect of this long-standing industry.

This question of why the supercycle ended so badly for the industry inspired this book, prompting us to seek answers from leaders of some of the world's most important mining companies.

Their responses confirm that the causes of the mining industry's problems are deep and complex and have run throughout its history. The supercycle simply made these issues more evident, encouraging a period of reflection and subsequent change in direction which, if maintained, should create a more resilient industry.

We trust that the twelve leadership lessons identified in this book will provide valuable and constructive insights into what was a difficult time and also offer succeeding generations entering the industry with a useful record of what needs to be avoided, changed and strengthened when managing a mining company.

The book's title, *Mining for Value*, succinctly encapsulates two overarching lessons: the need for leaders to focus on value creation over the long term and the need to be guided by strong company values. The result will be strategic, disciplined, diverse and innovative organisations capable of responding to the different expectations of increasingly demanding stakeholders.

Despite the slight bias towards the copper industry in the Americas, explained by the fact that the work originated and mainly involved companies operating in that region, the findings are valid for the industry globally.

We would like to thank the interviewees for their valuable time and contributions. Their candid and often self-critical insights have helped make this a unique record of the experience of industry leaders during the heady days of the supercycle. Just as valuable are their views on the future challenges facing the mining industry.

Emily Russell made the writing of this book possible. She played a fundamental role in the interviews and shaped them into a narrative that became the book's twelve lessons. Her writing captures the spontaneity of the interviews and the demanding task of combining first-hand accounts with the analytical purpose underlying the book.

Alejandra Wood from Cesco and Alastair Rolfe from Spencer Stuart played a crucial role in supporting the book's production, providing comments and taking care of the publication logistics.

Jose Joaquin Jara from Cesco was responsible for putting together much of the statistical data. Manuel Córdova drew the illustrations that lend a visual and slightly light-hearted quality to each of the lessons. Keith Fryer from Spencer Stuart was responsible for the book's design.

We thank Barclays, Boston Consulting Group, Cochilco, CRU, EY, Export Development Canada, ICMM, Metal Bulletin, PwC, Sergnageomin and Tetra Tech for allowing us to replicate their data in a number of charts.

Finally, we wish to thank the London Metal Exchange for their generous support in launching this book in London during LME Week 2018.

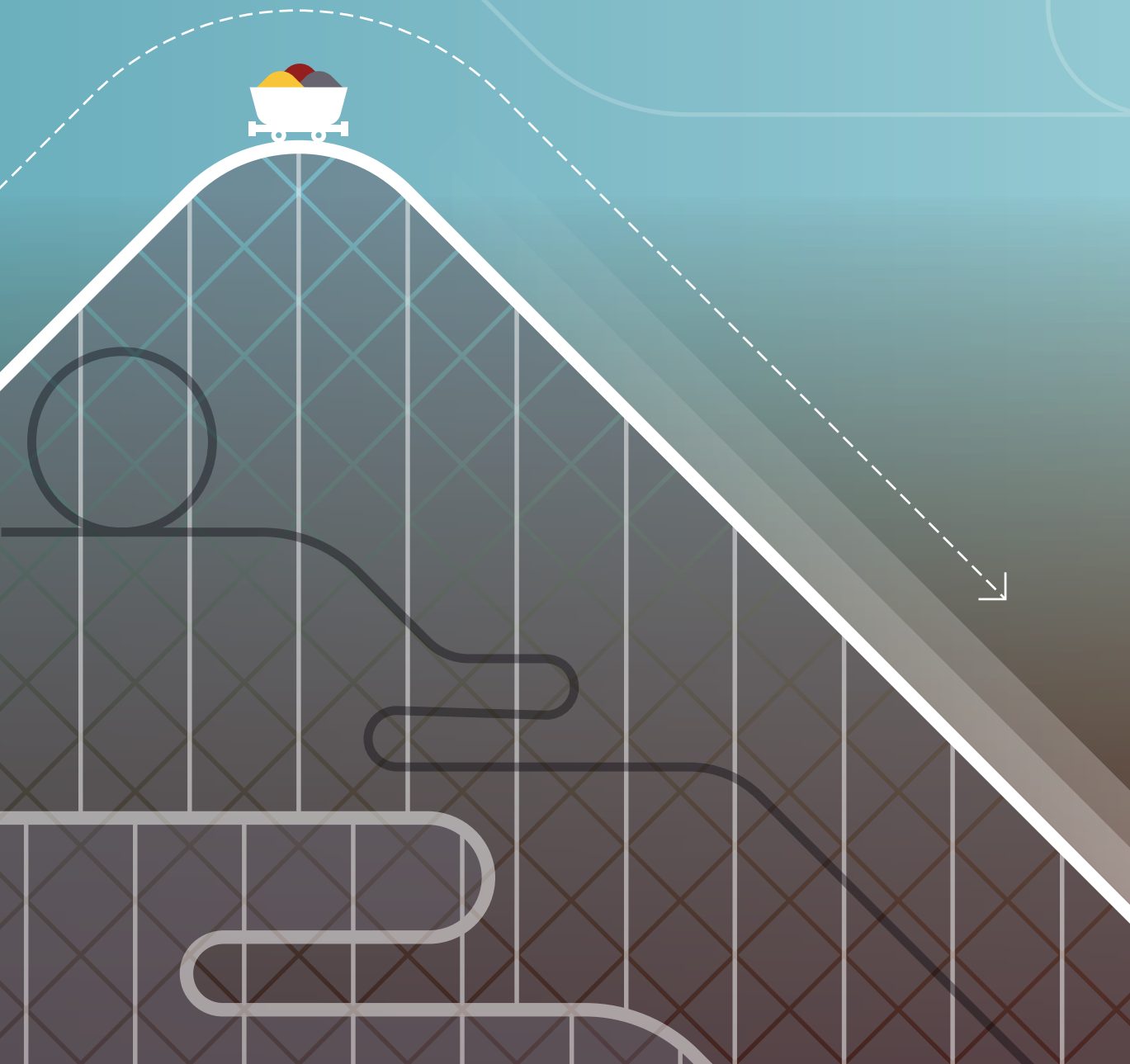
Jorge Bande
MEMBER OF THE BOARD, CESCO

José Luis Barroilhet
CONSULTANT, SPENCER STUART

LESSON ONE

Don’t forget: cycles don’t last forever

Booms always turn to bust



Commodity price cycles are a constant challenge for the mining industry and always will be. When metal supply is unable to keep up with unexpected strong demand, the industry enters a bull market and prices rise. As the industry gradually meets demand by increasing production, a supply surplus materialises, prices weaken, and the bear market begins. There are stronger cycles and weaker ones but they have one thing in common: they all come to an end.

"Our business is to survive when prices are low and to be as present as possible when prices are high. This is the great secret of our industry," says Diego Hernández, president of Chilean mining association Sonami. Such a strategy involves keeping production costs on or below the industry average to remain afloat in downturns and being able to boost production to rake in the cash during upswings, he says. In the case of the 2004–2014 so-called commodities "supercycle", mining companies fell into the trap of thinking the cycle was never going to end, says Hernández, an industry veteran who has led some of the world's largest mining companies.

The remarkable speed, length, and strength of the 2000s supercycle took most industry players by surprise (see figure 1.1). Miners, boards, analysts, investors, and bankers alike were not prepared when demand for commodities took off early this century, peaking in 2011 at 33% above long-term trends (Bank of Canada, 2016). They were also caught out when metal prices collapsed from mid-2014. The price rally was driven by China's unprecedented demand for base metals to feed its commodity-hungry urbanisation programme, requiring massive expansions in infrastructure and housing. The Asian giant grew from consuming roughly 13% of the world's industrial metals in 2000 to more than 50% today (see figure 1.2).

"The change was so profound and fast by historical standards that its impact on global trade can be compared to finding a new continent, like when America was first discovered," says Iván Arriagada, chief executive of Antofagasta plc. It was game changing as a whole

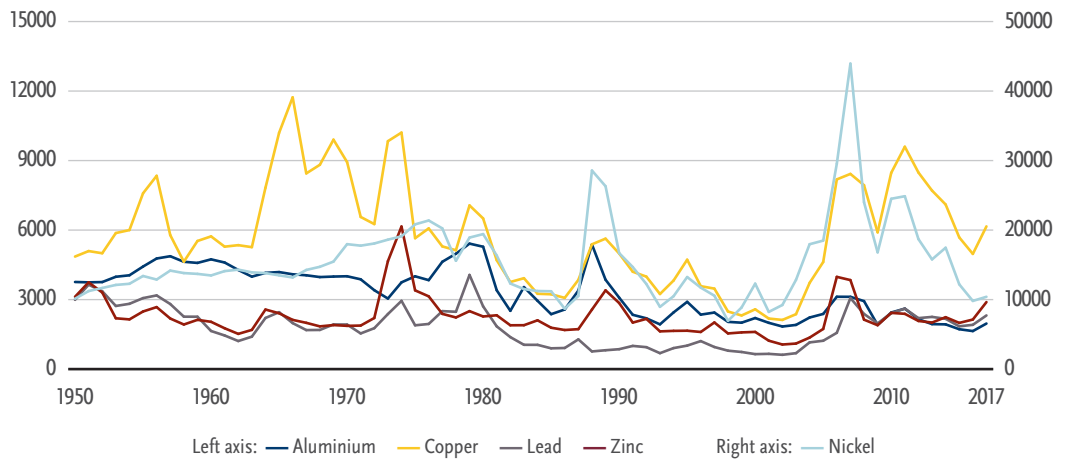
new demand for metals from new economic activity came on to the scene, he recalls. “The industry forgot it was a cyclical business. It forgot that productivity and costs are important and the main factors behind competitiveness.”

The scale of China’s rapid urbanisation was unprecedented and is a phenomenon unlikely to be repeated, according to many industry leaders interviewed for this book. The situation was accentuated by a dearth of new supply to meet demand after a long period of under-investment stretching back to the late 1990s. Adding to this already potent mix, commodities abruptly emerged as an alternative investment vehicle — exacerbating the cycle’s volatility. Large institutional investors began pouring money into commodities through indices, medium-term notes (MTN) and exchange-traded funds (ETF, see figure 1.3).

Encouraged by boards and investors, mining company leaders went on a growth spending-spree to catch up with demand. Mergers and acquisitions activity accelerated dramatically, as did the development of expansions to existing mines, as well as spending on greenfield projects. Healthy cash flows and investor speculation — fuelling a generous supply of debt from financial institutions — helped fund

Figure 1.1: Base metals prices 1950-2017

US$/t, constant 2017 US$



Source: Metal Bulletin

miners' ambitions to consolidate market positions. Many companies spent too much money chasing tonnes that were not needed, compounded by the availability of cheap debt, says the chief executive of Anglo American, Mark Cutifani. "There was simply too much money in the system."

As companies simultaneously sought to increase production, heated competition for engineering, procurement and construction management (EPCM) capabilities and equipment caused costs to rise. But the industry's appetite remained undiminished, as did banks' desire to providing funding, sometimes allowing marginal projects to be approved and built (see Lesson 8 on project development).

Even when China dropped from double-digit GDP growth to levels of 9.5% in 2011 and then 7–8% from 2012, its sheer market size and the common view that voracious demand would spread from China to other emerging countries were still expected to drive elevated metal consumption. On the supply side, punters pointed to the lack of new first-class mineral projects and longer development schedules on which to base unfounded predictions of sustained high metal prices.

The end of the story is well known: when commodity prices plummeted, the mining industry drastically cut its workforce, slashed capital spending, and scrapped dividend payments in search of healthy balance sheets. Billions of dollars were hacked from the book value of debt-fuelled acquisitions made too late in the cycle, sometimes at its peak. Dozens of greenfield projects worldwide suffered huge overruns and delays. Divestment plans were announced to pay off hefty debt.

Few mining companies were left unscathed, including notorious examples among the major global diversified miners. Rio Tinto wrote down about two-thirds of its 2007 US$38 billion acquisition of Canadian aluminium company Alcan, then the largest mining deal on record. Anglo American's 2008 acquisition and development of the Minas-Rio iron ore project in Brazil went into operation four years late in 2014 and at twice its original budget. BHP's US$4.75 billion investment in Fayetteville Shale in the US in 2011 was written down by US$2.8 billion just a year later, after gas prices dropped. Glencore's 2013 takeover of

“The industry forgot it was a cyclical business. It forgot that productivity and costs are important and the main factors behind competitiveness.”

IVÁN ARRIAGADA
CHIEF EXECUTIVE,
ANTOFAGASTA

Xstrata took impairment charges of US$7.7 billion only a few months after the tie-up was completed as commodity prices weakened.

Companies that made acquisitions or brought on new production at the start of the upswing were able to reap handsome rewards. Asset valuations and capital costs were not yet inflated and companies were able to pay for investments while prices were high. But those leaving it to later in the cycle often overpaid for assets or project development and were faced with high debt just as prices tumbled.

"The industry lost its ability to manage itself. It got very reactive. It reacted to a period of weak prices in the 1990s and then, as everyone knows, it overreacted to a period of strong prices at the top of the supercycle."

DOUGLAS UPTON
INVESTMENT ANALYST, CAPITAL GROUP

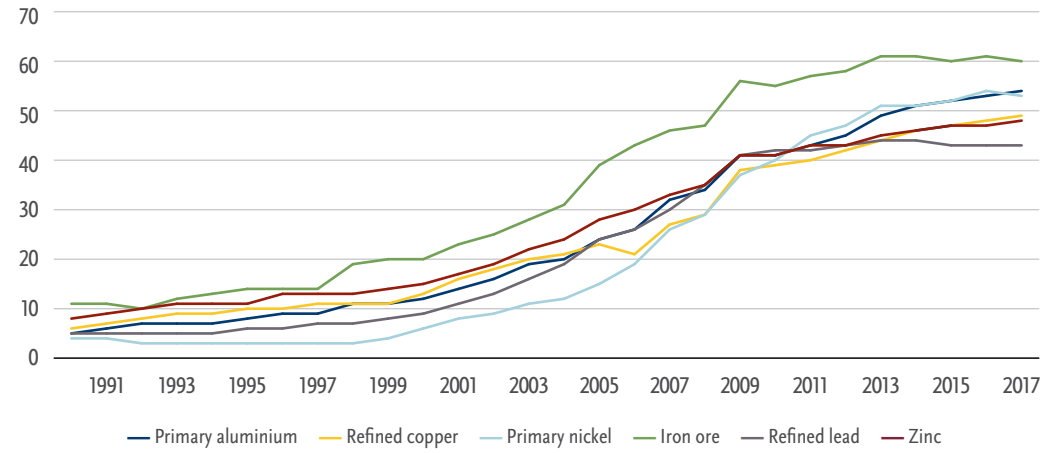
"If there was a mistake, it was the excessive indebtedness of some companies that believed towards the end of the supercycle that it had no end and they got into debt and a complex situation," says Hernández. Things would have been a lot worse had it not been for the 2008 subprime crisis that briefly interrupted the upswing, alerting indebted companies to renegotiate terms, he adds.

Some economists argue that the 2000s commodity price boom followed a supercycle pattern represented by periods of rapid industrialisation, requiring strong metal consumption, such as the US industrial revolution at the turn of the 1900s, rearmament in the 1930s, and reconstruction after the Second World War. With the benefit of hindsight, it is possible to say that incipient signs of China's future strong growth were there in the 1980s but industry leaders agree that cycles are very difficult to predict.

Even by the early 2000s, companies were still not convinced of China's coming impact. When state trading house China Minmetals went to London in 2002 to discuss the country's rocketing metal needs with potential partners, "not many were really convinced," says Jerry Jiao, chief executive of MMG, a mining subsidiary of the Chinese state company. "Few believed it. They felt this is a really big jump. Even for us — who'd done the calculations — it was a shock."

Figure 1.2: China's share of global metal demand

1991–2017, percent



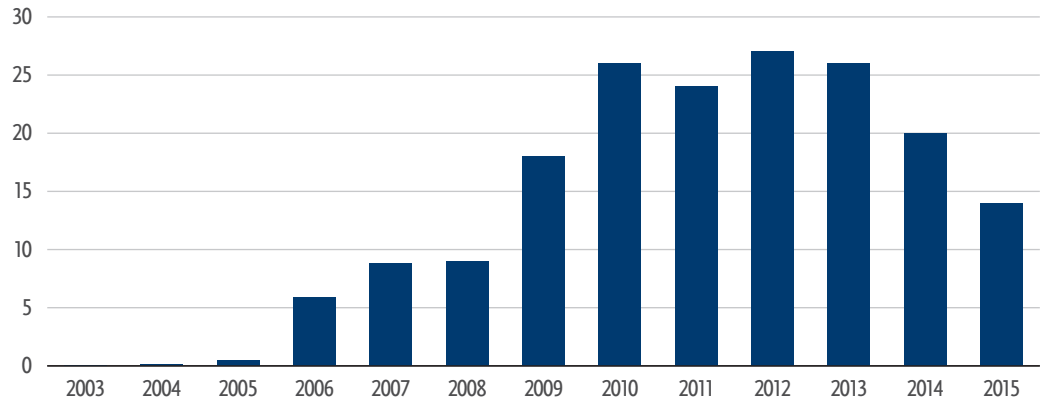
Source: CRU

For Douglas Upton, an investment analyst at Capital Group, the drivers of the 2000s supercycle were not just to do with China but also with a lack of industry investment in the late 1990s after a period of low prices. In-house engineering and geological capabilities had been reduced significantly and by 2003–2004 metal supply was not even keeping up with trend demand, let alone China's extra demand, according to Upton. "I think what we call the supercycle was as much an under-supply cycle as a demand cycle," he says. "The industry lost its ability to manage itself. It got very reactive. It reacted to a period of weak prices in the 1990s and then, as everyone knows, it over-reacted to a period of strong prices at the top of the supercycle."

It is difficult for companies to align production with cycles, says Upton. "It's really hard to call the cycles and get them right. I haven't ever seen a mining company built for that." Instead companies need to focus on establishing a strong set of long-term prices and exchange rate assumptions to use for feasibility study and project approvals, he argues, adding that today there is not sufficient focus on cost structures in the determination of pricing assumptions.

Figure 1.3: Financial investments in base metals funds

Assets under management (AUM) in US$bn



Source: Cesco, based on Barclays Capital reports. The series includes investments on base metals indices, exchange-traded products (ETP), medium-term notes (MTN) and others funds.

The mining industry tends to exaggerate, agrees Daniel Malchuk, president of BHP's Minerals Americas business. "The mood swings of the industry are extremely notable, more so among the people that work around the industry than the industry itself." When prices rise, euphoria rules; when they fall, the doldrums set in. We should all maintain an "average-cycle mentality" when working in a complex cyclical industry such as mining and not get too desperate when prices are low or too excited when they are high, he says. "We pay attention to the cycle but at the end of the day it's very hard to predict. People who say they'll enter the market when prices rise ... It's impossible."

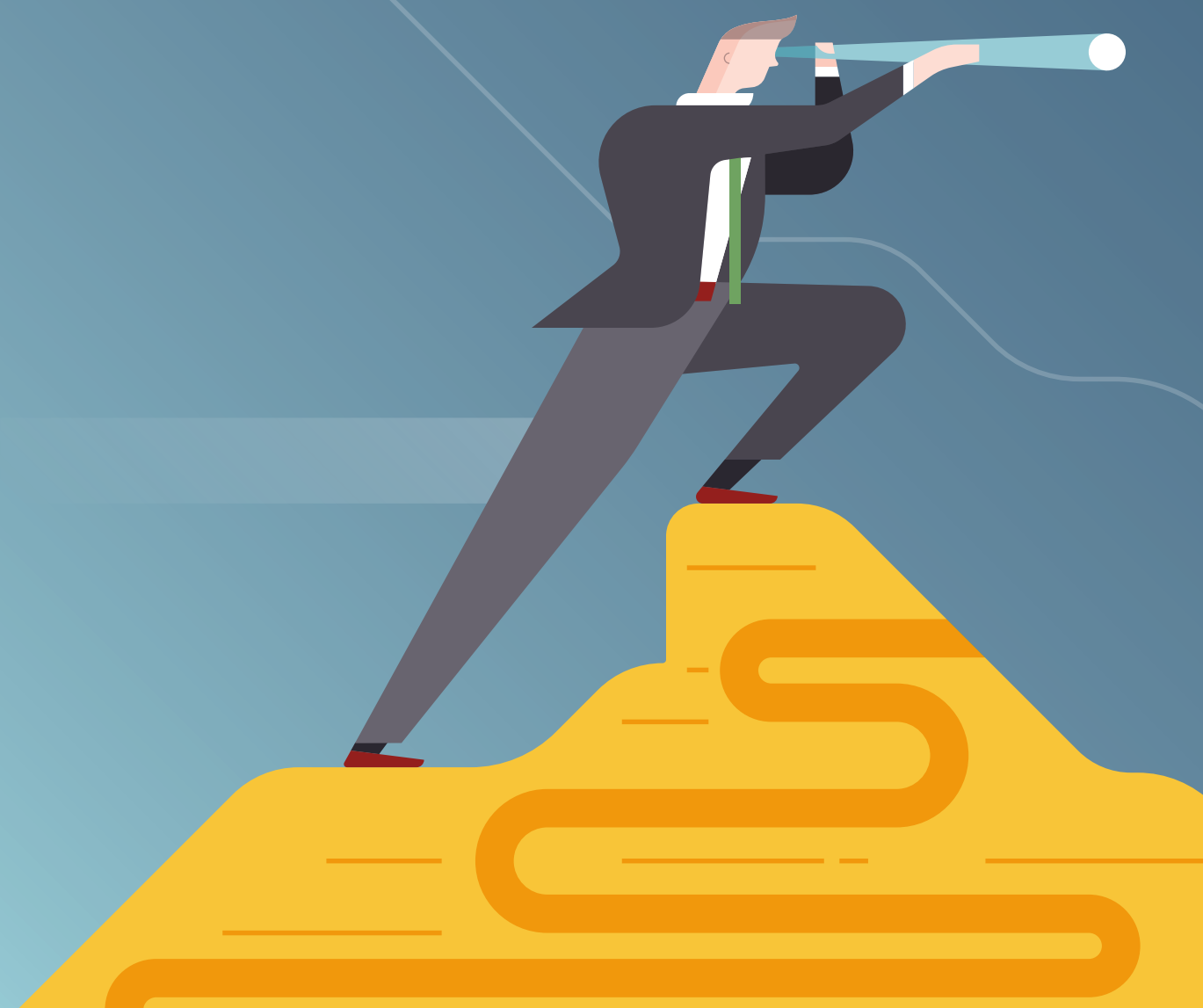
Companies need to strive to be counter-cyclical, industry leaders agree, along the lines of Warren Buffett's famous line: "Be fearful when others are greedy, greedy when others are fearful." In this way, mining companies can reserve cash for investments when prices are less swollen and be more prepared to reap the benefits of the upswing the next time it comes around.

Cycles may be hard to predict but one thing is known for sure: all cycles have an end.

LESSON TWO

Ensure rigorous, long-term decision-making

Short-term gains can cause long-term pains



Faced with the volatility and unpredictability of commodity cycles, mining companies must take decisions based on a long-term vision underpinned by robust strategic planning. This is particularly true for an industry such as mining where decisions, once made, are difficult to change.

High upfront capital investment and subsequent sustaining capital expenditures, plus costs for end-of-mine-life rehabilitation mean that growth projects, once started, are hard to stop. For existing operations, long lead times hinder swift responses to cycle upswings; likewise, costs cannot easily be reined in when demand slackens and prices drop.

"Our supply is not elastic: we don't have the ability to respond rapidly, and our supply is not flexible because it is difficult to increase or reduce the size of a mining operation. These two conditions are set in stone," says Jorge Gómez, chief executive of northern Chile's Collahuasi copper mine, one of the world's largest. When a mining company makes a wrong decision, it is not possible to just do a U-turn and turn back as one would do in a car, he says. "The road one follows has to be well-planned because the way back from a wrong-turn is very long or almost infinite or impossible."

A long-term outlook that sees beyond the peaks and troughs of the commodity cycle is a determining success factor. "The main learning for us is that it is absolutely critical to have rigour in managing your business, which holds true regardless of where you are in the cycle. The key is to think strategically over the long term and to focus on high-quality assets in commodities with sound long-term fundamentals," says Arnaud Soirat, Rio Tinto's CEO Copper & Diamonds. "I believe if we maintain this rigour through the cycle — it will be tough, it will be tested — it will create shareholder value. If you look at the supercycle, a lot of value was destroyed."

Daniel Malchuk, president of BHP's Minerals Americas, agrees. Although commodity spot prices will influence five-year budget plans, companies need to focus on supply and demand fundamentals over a 10- to 15-year timeframe, he says. A long-term industry needs to avoid being tempted by the short-term outlook. "The big decisions have to be supported by a long-term vision of the industry and not by what is happening on a day-by-day basis," he says.

For companies with "tier one" assets — large deposits with growth options over many decades — this is an easier task. "What we are trying to do as a strategy in Rio Tinto is to position ourselves in tier one assets that can generate enough cash to be able to grow, even during the low part of the cycle, and I think that will create a competitive advantage," Soirat says. In addition, the company is investing against the cycle to develop its large Resolution and Oyu Tolgoi copper projects in the US and Mongolia respectively. These are long-life, low-cost and close to their customers.

"The key to success in the mining business is having good assets, ones with long lives and attractive cost structures," agrees Richard Adkerson, chief executive of Freeport-McMoRan. Together with a good balance sheet, these allow you to handle the variabilities of commodity markets and give you the optionality to participate. In addition, the company has "dynamic plans" that it updates every quarter — rather than annually — which helps it to react to volatile commodity prices. "We have a track record of responding to changes in commodity prices more quickly as a result," says Adkerson.

Strong leadership is required to resist pressure from investors and analysts, anxious about short-term profits, to hasten growth options when prices rise or decimate investment when they fall. Investors may create a "permissive environment" but companies have a responsibility to educate their shareholders, argues Capital Group investment analyst Douglas Upton. "I never saw a single company push back and argue the case for not investing [during the supercycle]," he says.

The responsibility here lies not only with boards, but also with senior management. "There is always pressure but I think we are paid to make choices and be held accountable for our choices," says Soirat. The chief executive of Chilean state copper company Codelco, Nelson Pizarro, agrees: "The main responsibility to deal with this situation falls on company executives. We need to maintain our vision on the medium-term and take decisions that incorporate volatility as a given factor. We mustn't overreact to cycles of high or low prices but seek an average that will lead us to take balanced and realistic decisions." He adds that accountability, in turn, is a powerful tool to improve management as transparency generates the incentives for continuous improvement.

Robust strategic intelligence will help companies to make the right long-term decisions as well as ride the turbulence of short-term events. The lesson here is to really listen to one's marketing business, according to the chief executive of Anglo American, Mark Cutifani. "We are now very focused on the downstream," he says. "What are the macro trends that will shape the future? For example, the importance of scrap to the long-term price of iron ore. Our radar needs to look over the radar."

Anglo American conducts detailed scenario planning in a similar way to the VUCA (volatility, uncertainty, complexity, ambiguity) model, explains Hennie Faul, who heads Anglo American's copper business. The model aims to understand what the most likely scenarios are in an increasingly complex business environment, due to globalisation, and to improve preparedness to operate under multiple outcomes. "One important lesson learned from the past is that the industry used to apply single-point forecasts, assuming it would be possible to foresee the future on that basis," he says. For example, in the early 2000s companies did not fully understand what was happening in China and the country still represents many uncertainties. Today, adds Faul, "we need to apply a more holistic view that helps us understand the most likely scenario that could unfold."

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ARNAUD SOIRAT
CEO COPPER & DIAMONDS,
RIO TINTO

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JORGE GÓMEZ
CHIEF EXECUTIVE, COLLAHUASI

Cultural diversity may also help build up a multi-layered perspective on possible different outcomes (see Lesson 10 on people). This is one of the benefits of partnering with a Chinese company, according to Jerry Jiao, chief executive of MMG, a mining company formed after the acquisition by China Minmetals in 2009 of the majority of assets of Australia's debt-burdened OZ Minerals. The experience of the OZ Minerals management team was regarded as a valuable resource for the Chinese newcomers, with OZ Minerals chief executive Andrew Michelmore taking the helm of MMG until his retirement in 2017.

"We initiated a concept to build something unique and combining East and West," recalls Jiao, a board member of MMG at the time. While OZ Minerals brought operational experience to the arrangement, China Minmetals brought a better understanding of the Asian giant's political and economic progress, he says. It can also provide access to competitive funding or — in downturns — possible counter-cyclical funding when other sources have dried up, as well as access to China Minmetals' large commercial network, he adds. MMG takes a long-term approach based on a horizon of 20-plus years, he says, helped by the fact that its major shareholder, China Minmetals — which holds approximately 74% of the company — shares this view.

Cycles may be hard to predict but a disciplined approach to maintaining long-term objectives based on robust intelligence will help companies surf the waves.

LESSON THREE

Never lose sight of core balance sheet discipline

And ensure competitive shareholder returns

In the heady days of the supercycle, many mining companies forgot the importance of maintaining healthy balance sheets in readiness for an eventual downswing. A disciplined approach to spending was swept aside as record commodity prices filled coffers and companies — encouraged by investors, analysts, and financial institutions — chased acquisitions and organic growth projects.

Even when prices were declining, the sector's capital spending in 2014 was still higher than in the 2009 financial crisis, despite a similar price environment, according to an EY analysis of 88 companies (EY, *Debt in the Mining Sector*, 2015). This was feeding into a considerable disconnect between declining earnings and rising net debt levels, according to EY (see figure 3.1).

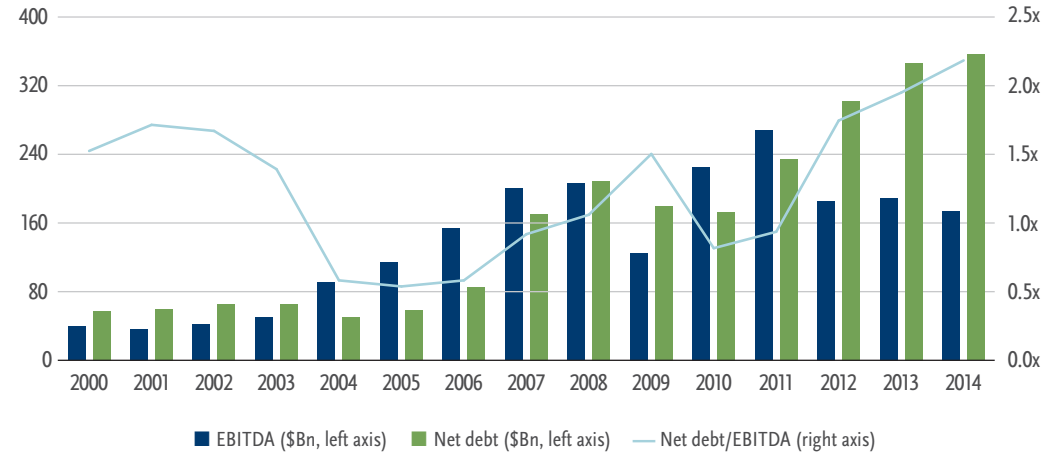
In the stampede for growth, the opportunity to reward investors was neglected, leaving them out-of-pocket when inflated market caps plummeted to decade lows in 2015. As average leverage levels reached decade highs that same year, companies slashed headcounts, sold off assets, and, adding insult to injury, suspended dividend payments. Speculators fled commodity markets, precipitating a sharper fall in commodity prices than might otherwise have been the case.

"The big mistake was pouring almost all the excess cash flow back into the industry at the top of the cycle," says Capital Group investment analyst Douglas Upton. Capital spending was so high in 2010 and 2011 that it outpaced the industry's potential cash flow generation while the capital intensity of projects had increased three-fold, he says. The industry ignored all the price signals telling them not to invest, the main one being the "massive inflation" in the unit cost of adding capacity, according to the analyst.

Upton suggests that companies use an indicator to determine whether capital should be reinvested or returned to shareholders. For example, when the ratio of the industry's market capitalisation compared to global market capitalisation falls below a 20-year trailing

Figure 3.1: Mining companies net debt to EBITDA ratio

Based on a sample of 88 listed mining companies



Source: EY, Debt in the Mining Sector, 2015, using data from S&P Capital IQ, EY research

average, he proposes capital be reinvested and, when the ratio is higher, companies dispose of excess capital via special dividends.

Companies need to have a disciplined capital allocation framework, says Daniel Malchuk, president of BHP's Minerals Americas business. Healthy competition for capital among a company's different projects or divisions contributes towards a more transparent, disciplined approach. In addition, capital spending is not necessarily the best way to resolve operational issues, he says. A more restrictive approach to capital can generate a "needs must" atmosphere in which creative solutions flourish, according to Malchuk.

Capital allocation is one of the three key principles with which the mining industry has struggled in the past but that need to be firmly in place, according to Hennie Faul, CEO Copper for Anglo American. "You've got to have that core balance sheet discipline: cash flow to fund your projects, very good capital allocation, and responsible risk management," he says. This is especially relevant in a hyper-cyclical, high-risk industry like mining, he adds. The strength that such

"In the base metals business you don't have a great benefit by being diverse in commodities because the forces that drive the demand picture for them are so highly correlated."

RICHARD ADKERSON
CHIEF EXECUTIVE,
FREEPORT-MCMORAN

discipline provides will help companies stand up to pressure from analysts and investors, who may be pursuing shorter-term gains, and will ensure the path of major sustainable growth, Faul believes.

"You need a strong balance sheet to avoid letting go of strong assets," says Richard Adkerson, chief executive of Arizona-based Freeport-McMoRan, the world's largest publicly traded copper producer. The company learned the hard way with its ill-timed 2013 US$19 billion oil and gas acquisition of Plains Exploration and McMoRan Exploration — after which oil prices roughly halved. In 2016 Freeport was forced to sell its 56% share of the large Tenke Fungurume copper and cobalt mine in the Democratic Republic of Congo to China Molybdenum for US$2.69 billion in cash to repay debt. It also had to sell an interest in its US Morenci mine as well as raise equity at a lower share price, according to Adkerson.

Freeport was not alone. Across the mining industry leverage levels were stretching balance sheets and limiting the ability of companies to absorb financial shocks. The situation was particularly critical given the industry's high sustaining capital requirements and its cyclical unpredictability. As the bear market set in, mining companies across the globe, and in all commodities, began active portfolio reshaping processes and reassessing development projects to lower debt and reduce capital spending. "We went back to basics; to reduce costs and improve productivity through our mine-to-market programme," recalls Arnaud Soirat, who heads Rio Tinto's Copper & Diamonds business. "We are allocating capital with rigour and discipline throughout the cycle," he says.

"The foundation is to have conservative balance sheets," says Upton. Lower debt levels and good debt durations are required to avoid repeating the slash and burn of 2009 and 2015, he adds. When prices turn down, a robust balance sheet will give companies the optionality to hold on to people, advance projects, maintain sustaining capital, pay dividends, sanction projects, and even to make an opportunistic acquisition, he says. These benefits more than offset the advantages that a heavier balance sheet might offer, in terms of optimising return on equity (ROE), argues Upton.

Codelco chief executive Nelson Pizarro agrees: "Mining companies need to be extremely prudent in maintaining a debt level and payment profile that is consistent with the volatility of cash flow and the capacity to cover payments in any price scenario." Given commodity price uncertainty, Pizarro believes it would be wiser to fund projects through a greater share of capital component.

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HENNIE FAUL
CEO COPPER,
ANGLO AMERICAN

Blinded by the supercycle's high cash flows and an anxiety to grow, the industry dropped its guard on responsible risk management. Companies inadequately factored in the cyclical nature of commodity markets, heightened financial risk that accompanies growing debt and inflated project development costs. At board level, there was a paucity of strategic thinking and a failure to appreciate the seven- to 10-year business risk period of mining, says the chief executive of Anglo American, Mark Cutifani.

Industry leaders agree that geographical diversification helps lower exposure to risk. However, not all miners agree on the benefits of commodity diversification. Freeport's copper business would have withstood the price volatility had it not been for the balance sheet difficulties the company faced due to the oil and gas foray, says Adkerson. "In the base metals business you don't have a great benefit by being diverse in commodities because the forces that drive the demand picture for them are so highly correlated," he notes. It is more important for the commodity to be "a good business to be in", he argues. He believes this is met by the "unique characteristics" of copper due to the metal's exposure to China and its supply scarcity.

In a capital-intensive, high-risk cyclical industry such as mining, it is paramount to focus on core balance sheet discipline. This will lead to efficient operations (see Lesson 5 on productivity), value-enhancing organic growth (see Lesson 7 on growth), and a healthy long-term business with robust and steady shareholder returns.

LESSON FOUR

Boards need to be balanced, experienced and firm

Know a thing or two

The boards of directors at mining companies have four main roles: selection of CEOs; capital allocation; constructively challenging and monitoring delivery of strategic analysis and direction; and setting the levels of risk appetite. In the diversified majors about half of board members usually come from the extractives industry, with the remainder coming from other businesses or the financial sector.

Boards often include a regulatory specialist. One or two members usually hold company executive positions while the majority are independent, non-executive directors. The aim is to provide a breadth of knowledge and experience that will provide a steady hand during good times and bad, to protect shareholder interests.

In hindsight, the steady hand was absent during the supercycle. Many companies (if not all) overspent on growth, either through mergers and acquisitions or project development. In addition, they failed to reward investors adequately when prices were high and then cut dividends, sometimes unnecessarily, when prices plummeted. Not surprisingly, investors were left angry.

There was a culture of silence during the supercycle with few people daring to "mess with success" after years of profits. Difficult conversations were postponed. Those who did raise concerns were usually overruled by a majority swept up in the euphoria of an extended period of seemingly never-ending high commodity prices. Investor and analyst pressure on companies to grow led boards to dismiss less-predatory CEOs in the upswing, only for their more acquisition-hungry replacements to be sent packing when balance sheets became overstretched. Major mining companies battled for market dominance with a series of mega-offers and counter-offers filling media headlines for years.

"People like to do these grandiose things. It comes down not to the discipline of your technical people but the egos of your CEOs, the egos of your board," says Kenneth Pickering, an independent

mining consultant and director of numerous mining companies since retiring from BHP in 2010 after 39 years. Rather than focusing on operational excellence, mining companies became distracted and lost millions of dollars on legal fees for aborted takeover offers or billions on successful ones, he says.

With hindsight it is apparent that management lacked financial restraint and boards failed to provide sufficient oversight of company decisions, says Hennie Faul, CEO of Anglo American's copper business. "We see time and time again that it's a human factor: people become emotional rather than wanting to be boring and focus on the principles of balance sheet discipline," he says. Strong leadership is required to resist getting caught up in the hype or influenced by comparisons with peers, as well as to convince boards that the strategy is right, he admits.

Figure 4.1: Mining in the headlines

During the supercycle, mining companies chased mergers and acquisitions and built up heavy debt

Sources: The Guardian (12 July 2007), The Telegraph (20 June 2009), The Sydney Morning Herald (3 August 2012), Bloomberg (29 January 2013), The New York Times (1 October 2015)

Today the boards of mining companies tend to have more members from non-mining backgrounds than in the past. Their broader business acumen can be an important contribution to the mining industry, which historically has been fairly inward-looking. Outsiders can provide a healthy critical view of embedded assumptions that may need updating and they can also drive innovation and change. Nonetheless, interviewees voiced concerns that non-mining directors may have insufficient knowledge of the industry and do not understand the long-term cyclical nature of the commodities business.

"Ensuring you have deep knowledge of project execution on your board and executive committee is essential."

MARK CUTIFANI
CHIEF EXECUTIVE,
ANGLO AMERICAN

"The boards of big mining companies no longer have many mining people and, to the extent they do, they have engineers rather than people with capital allocation expertise," says Capital Group investment analyst Douglas Upton. "They're not really set up for looking at the industry in the right long-term context." The short-term outlook and lack of experience of some board members accentuates the mistake of extrapolating what will happen in the future by looking at the past six months, he says. Because they are often not equipped to make capital-intensive decisions, boards are at risk of accepting a bad investment proposal, he adds.

Areas of weakness on boards include a lack of understanding of cash cost structures, the return on capital employed (ROCE), and the importance of value over volume, according to Mark Cutifani, the chief executive of Anglo American. Many boards do not fully appreciate the key margin points of the industry's complex value chain, which goes from mine development through to processing and product distribution, and the value of flexibility is lost on many. "Ensuring you have deep knowledge of project execution on your board and executive committee is essential," Cutifani adds.

Codelco chief executive Nelson Pizarro has similar concerns. Mine engineers or operators that develop proposals become emotionally attached to the projects, "fixing them up" with over-optimistic projected operational costs, he says. Company directors need to have

"People like to do these grandiose things. It comes down not to the discipline of your technical people but the egos of your CEOs, the egos of your board."

KENNETH PICKERING
INDEPENDENT MINING CONSULTANT AND COMPANY DIRECTOR

the necessary detachment and expertise to assess project promises with a clear head, thus preventing the approval of under-engineered and sanguine investment plans that resulted in the start-up delays and budget over-runs suffered during the supercycle.

Another issue, according to Upton, is the lack of time available for boards to discuss strategic planning, as they are too busy going through "tick lists of governance issues and risk controls". Another example is that boards are sometimes presented with complex Monte Carlo analyses on projects but do not have the time to understand what goes into the analysis, he says. This is particularly serious for a capital-intensive, cyclical industry such as mining.

Industry leaders place great value on experience, calling for older company directors who have been through a few commodity cycles. Yet none referred to the under-representation of women on the boards of mining companies, although studies suggest that a "critical mass" of 30% of women at board level or in senior management has a maximum positive impact on company performance. A 2015 joint survey of the top 500 globally listed mining companies by PwC and Women in Mining (UK) found that only 7.9% of company directors were women, with 11.1% representation in the top 100 mining companies *(Mining for talent: A study of women on boards in the mining industry*, 2015). The report found that the average number of women on boards in the mining sector lagged behind all industry sectors, except oil and gas, but it did show an improving trend.

Boards need to be experienced and firm but the right balance needs to be struck between an empowered board and an agile organisation, warns Iván Arriagada, chief executive of Antofagasta. If the pendulum swings too far towards increasing corporate bureaucracy, slower and too inward-looking organisations may fail to grasp opportunities.

LESSON FIVE

Don’t get distracted: Focus on operational excellence

Treat mining as a continuous production rather than batch process

As commodity prices began rising sharply from 2004, companies responded in time-old cyclical fashion by increasing production at existing operations to take advantage of higher prices. Mobile equipment and plants were driven hard to boost throughput capacity. Maintenance was sometimes overlooked at a high cost. Headcounts rose, along with salaries, as mining companies competed for the best, often scarce, qualified personnel. Contractors were brought in to boost the workforce. The inflationary environment drove up input costs.

Initially, increased unit costs tended to be offset by higher production and commodity prices. However, Boston Consulting Group (BCG) found that between 2010 and 2014 a sample of 101 mining companies delivered a median total shareholder return (TSR) of minus 18% (BCG, *Beyond Basic Productivity*, 2015). Of this, increased unit costs, coupled with a decline in operating margins, deleted a median of 7% from TSRs. Industry margins fell from 42% in 2010 and 2011 to 33% in 2013 with labour, consumables, and services representing some of the biggest areas of cost increases, according to the report (see figures 5.1 and 5.2).

These trends more than offset the economic benefit of increased production, with only one-third of companies experiencing profit growth over the same five years, it said. "Companies need to focus more sharply on returns rather than growth," concluded BCG.

Chilean mines were among the worst offenders. Mining costs in Chilean open-pit copper and gold mines grew between 14% and 15% a year from 2010 to 2013, according to BCG. Likewise, Chile's National Productivity Commission (CNP) found that the total factor productivity of the country's mining industry declined by around 1% per annum in the period 2000–2014 (Comisión Nacional de Productividad, 2017). "The price boom caused all companies to focus on production at the expense of productivity in order to take advantage of the unusual margins," it argued. The CNP's benchmark

Figure 5.1: Costs increases at surface copper mines

Costs per ton of material moved, excluding processing, logistics and overhead in US$

		Change in Mining Costs, 2010–2013					
	Costs 2010	Labour	Consumables	Services	Diesel fuel	Other	Costs 2013
Chile	$2.03	+0.39 (+19%)	+0.26 (+15%)	+0.22 (+12%)	+0.19 (+17%)	-0.08 (-30%)	$3.01 (+14%)
United States	$1.81	+0.13 (+8%)	+0.04 (+2%)	+0.05 (+5%)	+0.00 (+0%)	-0.00 (-1%)	$2.03 (+4%)
Peru	$1.30	+0.02 (+2%)	+0.21 (+13%)	+0.08 (+12%)	+0.17 (+15%)	+0.04 (+36%)	$1.82 (+12%)
Canada	$1.74	+0.03 (+1%)	+0.13 (+12%)	+0.13 (+16%)	+0.01 (+1%)	+0.00 (+2%)	$2.03 (+5%)
Australia	$3.03	+0.12 (+5%)	+0.33 (+10%)	+0.31 (+15%)	-0.02 (-1%)	+0.21 (+191%)	$3.98 (+10%)
Zambia	$2.46	-0.01 (-1%)	-0.27 (-9%)	-0.26 (-14%)	+0.45 (+35%)	+0.11 (+52%)	$2.47 (+0%)
DR. Congo	$4.38	+0.11 (+8%)	+0.36 (+8%)	+0.15 (+3%)	+0.04 (+1%)	+0.01 (+2%)	$5.06 (+5%)

Note: Values in parenthesis are the average annual percentage increases. "Other" includes such costs as electricity and contractors.
Sources: BCG, Beyond Basic Productivity, 2015, using data from Wood Mackenzie; BCG Analysis

analysis of 12 local large-scale operations with seven selected international best-practice mines found that productivity levels in the Chilean mines were far lower than the comparison group. Some of this was attributable to the country's regulations but most was due to operational inefficiencies.

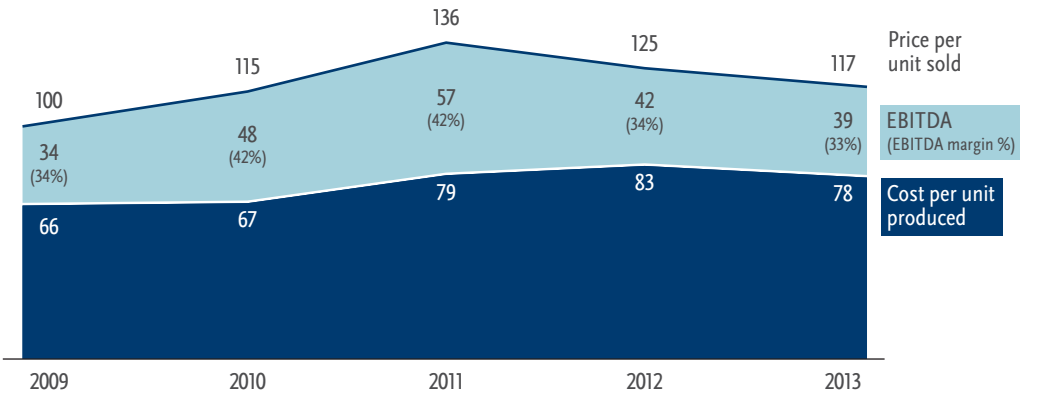
Labour costs have also soared in South Africa, once the world's largest gold producer but in sixth place today. Labour costs range from 20%–25% of total production for modern, mechanised, open pit mines compared to 50%-60% for mature, deep-level underground mines (EY, *Productivity in mining, a case for broad transformation*, 2017). Productivity in South Africa's gold mining industry has declined by 35% since 2007, according to EY. "While workers may aspire for higher real wages, during weak commodity price cycles the dialog should be focused on achieving productivity improvements to pay for this," it said.

Industry leaders agree that mining companies were distracted from operational competitiveness during the supercycle. "The most important lesson is that the industry lost its main focus: above all remaining competitive," says Daniel Malchuk, president of BHP's Minerals Americas. The industry got swept away by ambitious growth plans rather than "sticking to their knitting" and ensuring an efficient, low-cost business, asserts mining veteran and consultant Kenneth Pickering.

"As an industry we have to accept that we didn't take the precaution of being more austere and prioritising our focus on costs," says Jorge Gómez, chief executive of Collahuasi, a joint venture between Anglo American (44%), Glencore (44%) and a Japanese consortium led by Mitsui (12%). Instead, after the eruption of demand from China, attention was concentrated on putting tonnes into the market. When Gómez took the helm of Collahuasi at the end of 2012 the high-potential operation had suffered high CEO turnover, bitter labour disputes and equipment failures. Production had declined for three consecutive years after record output in 2009.

Figure 5.2: Evolution of commodity prices and unit costs 2009–2013

Indexed at 2009 prices



Source: BCG, Beyond Basic Productivity, 2015, based on data from Bloomberg, SNL Metals & Mining and annual reports, and BCG analysis.

Gómez led a successful plan to stabilise the operation. "We put things in order, focused, simplified many things and, regrettably, had to reduce our headcount," he recalls. Cash costs were brought under control as productive capacity was restored. The company had the foresight to suspend the higher-cost SX-EW plant before prices crashed at the end of 2015. A key part of the process was creating a common organisational purpose behind the need to improve safety. To date, Collahuasi has reduced C1 cash costs by 40% and is one of the lowest-cost operations in Chile.

"The key to success is to be disciplined in everything," says Gómez. "Not only in attitude, but in organisation, spending, use of capital, schedules, everything." An organisation without discipline cannot be successful, he stresses.

For mining companies to weather the ups and downs of commodity cycles it is vital for operations to be well-positioned on the cost curve (showing the cost per tonne of production). "You can't avoid the price volatility: the fundamental principle of mining is to have a low-cost mine life," affirms Jerry Jiao, chief executive of MMG. Companies may strategically prepare themselves for growth through acquisitions but these ambitions are dependent on many factors such as the other party, he says. "What we can do — what is 100% in our control — is everyday operational improvement."

Traditionally the mining industry has worked on the assumption that scale is the counterpart of wider margins and focused on throughput measures rather than productivity. The premise was that volume always implied value. However, as the BCG report indicates, this idea was challenged by the value destruction seen in the supercycle. "The key driver in all that we do is to add value and not to maximise volume," says Iván Arriagada, chief executive of Antofagasta. The idea of "profitable tonnes", as Antofagasta refers to them, has changed mining plans and decision-making, he says.

Rio Tinto's CEO Copper & Diamonds, Arnaud Soirat, agrees. "It's not about volume, it's about value," he says. For example, when Soirat ran Rio Tinto's aluminium business, the company reduced production of aluminium by 30% and alumina by 20% and

simultaneously significantly decreased unit costs from the 50th to the fifth percentile of the cash curve, he recalls. When the downturn came, the company focused on looking for value over volume and aims to maintain this rigorous way of managing the business and maximising cash even as markets improve, he says. And, he adds, "I am absolutely convinced that Rio Tinto is now a stronger company than it was even during the supercycle."

BCG recommends that the mining industry take a "holistic" approach to productivity, advising companies not only to seek improvements of their physical assets but also their management systems (including the selection of contractors and other sourcing decisions) and people excellence. This overall vision of optimisation was shared by the CNP's report on productivity in Chile's large-scale mining industry. Comparative international best-practice operations sought to maximise overall efficiencies rather than the isolated, bottleneck improvements of productive processes that reflected some Chilean operations, said CNP.

This feeds into a key concept and challenge for the industry as a whole: its traditional approach of treating mining as a batch rather than a continuous production process. It has led to a silo mentality in which different, often conflicting, performance and incentive indicators are set for mine and plant operations. Closer coordination and integration of these operations, fostered by overall site targets, will result in more efficient operations.

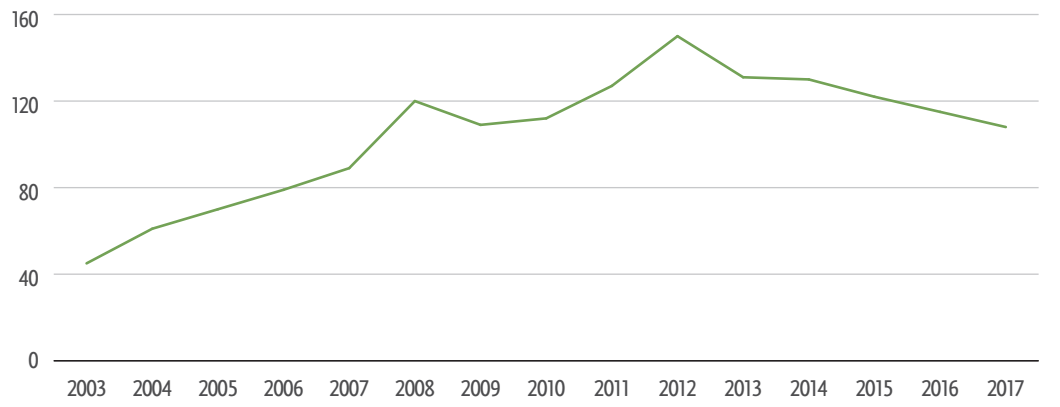
"The industry should learn from the manufacturing industry and treat it more as a production process," says Anglo American's chief executive Mark Cutifani. This approach, built on lessons from the automotive and aircraft industries, is behind the new global operating model that the company has been rolling out since 2014. It involves detailed target setting, scheduling, planning, execution, and follow-up to measure compliance with the plan, followed by analysis to ensure continuous improvement. The aim is to introduce stability, reduce variability and provide clarity on roles across the company's mining operations. Maintaining the discipline of planned work is a key aspect of the model.

“You can’t avoid the price volatility: the fundamental principle of mining is to have a low-cost mine life.”

JERRY JIAO
CHIEF EXECUTIVE, MMG

Figure 5.3: Net operating costs of top 10 copper mining companies in 2017

Costs in US$bn



Source: Cesco. Xstrata/Glencore is excluded due to methodological issues

The new operating model has been at the heart of an 80% improvement to productivity (as measured by copper equivalent units produced per employee) since 2012 when Cutifani took the helm, according to the company. It credits a combination of the operating model and a wider upgrading of the asset portfolio for Anglo American producing 9% more physical product at a 26% lower unit cost, from 47% fewer assets, compared with 2012. The new model functions in tandem with the company's push to rebuild in-house technical excellence by leveraging its technological knowledge, as well as to promote technological innovation that will drive further productivity improvements (see Lesson 6 on innovation).

The failure of the industry to stick to scheduled maintenance shutdowns on the false premise of meeting or beating production targets was another common feature of the supercycle. "I can think of people that run the mine to the ground for a year, or a year and a half, and then it falls to pieces," says Malchuk. He agrees with the need to adopt a "manufacturing industry mentality" to run more predictable operations. Safety focus, discipline, and a systematic

approach are required to ensure stable and sustainable operations over the long term, rather than falling prey to the temptation of short-term gains, he says.

Chilean state copper miner Codelco responded to escalating costs by creating in 2015 a new executive function, the vice-presidency of productivity and costs, and launching a productivity awareness campaign. This has been instrumental in achieving important cost controls, says Codelco chief executive Nelson Pizarro. Together with setting "challenging" key performance indicators (KPIs), it is fundamental to follow-up compliance effectively with these goals remotely via terminals, he maintains. For this purpose, the company set up a control room at Codelco's head office in Santiago to show remotely the real-time operational processes at its mines dispersed around the country. It allows the company to make rapid operational adjustments and also strengthens the handling of operational issues that might otherwise be swept under the carpet by local teams.

> "The key driver in all that we do is to add value and not to maximise volume."
>
> **IVÁN ARRIAGADA**
> CHIEF EXECUTIVE, ANTOFAGASTA

In addition, the application of the lean management model, in which a multi-disciplinary team tackles bottlenecks, has allowed Codelco to reduce consumption of reagents, fuel, and steel and to extend tyre life, according to Pizarro. In the period 2013–2017, the company improved labour productivity by 29% and drove down costs by 20%, despite a decrease in head grade of 10% over the same period.

Automation is clearly a fundamental input for productivity but it is still not widely used by the mining industry (see Lesson 6 on innovation). In the case of Codelco's newest and most productive mine, Ministro Hales, processes are operated remotely from a control room in Santiago but this has not yet been extended to the company's other operations. Likewise, the company's driverless trucks at its Gabriela Mistral mine are achieving utilisation rates of almost 17 hours out of 24, higher than any of its other operations where trucks are driven manually. It is the only mine in Chile to use automated trucks.

Miners are often described as "stubborn" and "proud", tending to be resistant to change (see also Lesson 10 on human resources). A new generation of younger, technically savvy workers will help pave the way for greater adoption of technology and innovation by the industry. Nonetheless, experience counts. Freeport-McMoRan runs all of its businesses in the Americas as a single entity, which makes it easier for the company to transfer people, use resources and technology, and share experience, says company chief executive Richard Adkerson. This team's knowledge has given the company the strength to deal with issues at complex projects in less-mature mining jurisdictions such as Tenke Fungurume in the Democratic Republic of Congo (divested in 2016) and Grasberg in Indonesia. "It's good to fall back on experience," he says.

"The key to success is to be disciplined in everything. Not only in attitude, but in organisation, spending, use of capital, schedules, everything."

JORGE GÓMEZ
CHIEF EXECUTIVE, COLLAHUASI

Strong leadership is clearly crucial to achieving operational excellence; it also needs to be stable. The CNP report into productivity in Chile's mining sector found that low turnover of senior management is required to maintain a company's approved strategy. In addition, bonuses should be focused on overall site components rather than isolated processes, a practice which "generates significant efficiency losses in the transfer of one process to another", it says. "Companies must reduce the rotation of senior executives, seek overall optimisation, and use variable remuneration and compensation mechanisms linked to profits and global indicators."

The test will be whether companies' newfound interest in value over volume will resist the next cycle of high prices or whether they will press revert to "factory settings" and allow considerations of cost to fly to the wind as they once again chase production growth.

LESSON SIX

Don’t delay innovation and technical change

Keep ahead of the game

Innovation and technology can help mining companies resist the volatility of commodity cycles — and to keep pace with today's rapidly changing world. Pioneering companies will enjoy higher margins sooner in the good times and be less exposed when the bad times roll in. Automation can ease the ebb and flow of soaring headcounts when commodity prices rise and large-scale dismissals when they fall. Among other benefits, predictive data can reduce unplanned maintenance outages and analytics can help to calculate optimum operational flows for individual plants depending on the specifications of the ore feed.

Unfortunately, however, mining is not known for its innovation. Nor has the industry looked elsewhere for inspiration: it has tended to be inward-looking and self-sufficient. "Innovation has historically been slow reaching the mining industry unlike other sectors, such as retail, telecommunications, which learned the lessons years ago," comments Iván Arriagada, chief executive of Antofagasta. Some large mining companies still require thousands of people to work at remote sites, whereas manufacturing industries incorporated automation long ago to keep labour costs under control, he says.

Even when proven technology exists, the industry is often reluctant or slow to use it. EY management consultants rated "Digital Effectiveness" as the number one risk for the mining metals industry in 2017–2018 (EY, *Top 10 business risks facing mining and metals* 2017, see figure 6.1). "While the concept of digital mining is not new, there is disconnect between the potential from digital transformation and the successful implementation of new technologies," according to an EY survey of 700 industry representatives. Although the majority of those surveyed have started the digital journey, the bulk of activities were on initial, small-scale "no regrets" projects, it found. EY urges

miners to focus on using digitalisation to solve the "most urgent" business problem: improving productivity and margins across the value chain.

The case in Chile is notable. The country's National Productivity Commission report (CNP, Comisión Nacional de Productividad, 2017) found that although local large-scale mines had similar operational positions, control centres, and levels of technology and equipment to international best-practice sites, they underused the technology, with negative impacts on productivity, compared to intensive use by their international peers.

The fear during the supercycle was that automated machinery could fail and the site would be called to account for lower-than-forecast production, explains Diego Hernández, president of Chilean mining association Sonami. Automation would often only be used when the operator went for lunch, he says, despite the fact that a plant with good automation control is more efficient than a plant run manually.

Figure 6.1: Top 10 business risks for mining

2017 rank	Risk	2016 rank
1	Digital effectiveness	New
2	Competitive shareholder returns	New
3	Cyber	▲9
4	New world commodities	New
5	Regulatory risk	New
6	Cash optimisation	▼1
7	Social licence to operate	▼4
8	Resource replacement	New
9	Access to and optimisation of energy	▼7
10	Managing joint ventures	▼8

Source: EY Top 10 Business Risks for Mining and Metals 2017-2018

“There needs to be a step-change in the use of technology to improve performance.”

DANIEL MALCHUK
PRESIDENT MINERALS AMERICAS, BHP

The mining industry's capital-intensive nature and the need to mitigate risk lies behind miners' reluctance to innovate and introduce new technologies, says Hernández: "Using new technology increases the uncertainty and thus the risk." The concern is that new technology may increase capital costs, delay project start-ups and not meet design capacity. The opportunity to implement technological change is when prices are low, he believes.

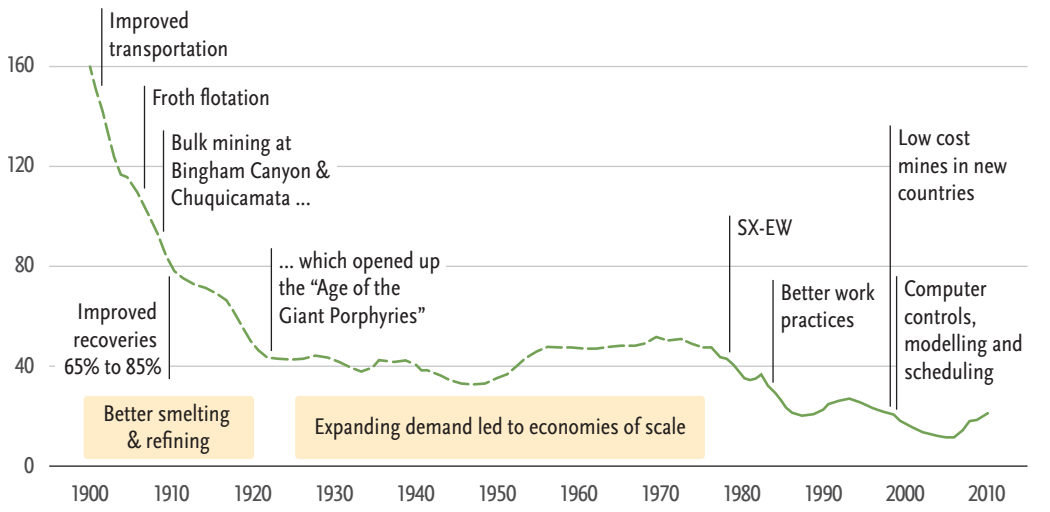
Another factor behind the industry's delay in implementing automation is its impact on the workforce. Automation reduces headcounts, requires different skills, and has encountered resistance from workers. The driverless haulage trucks at Codelco's Gabriela Mistral mine took years to meet productivity targets (see Lesson 5 on productivity), which involved collaboration with the technology's designers. The company had to "overcome the resistance of operators and open pit designers, and give an opportunity to the manufacturer to continue updating its software and hardware," says Codelco chief executive Nelson Pizarro.

Automation may also involve a different value proposition for community relations where the promise of well-paid jobs and training has traditionally formed part of a company's social contract with local stakeholders, according to Arnaud Soirat, CEO of Rio Tinto's Copper & Diamonds business. "I think automation is going to be a big challenge for our social licence to operate," he says.

Nonetheless, Rio Tinto regards itself as a pioneer among the mining industry for its innovation and technological advances. For example, the company's Pilbara iron ore operations in Australia is a front-runner in the use of automation: its mines, ports, and rail systems are operated from a single operations centre in Perth; it has the largest system of autonomous haulage trucks; and an expanding autonomous drilling system. The company recently trialled a fully autonomous train at Pilbara, says Soirat. He challenges the accepted wisdom that the first company to employ technology will not do well, but its experience will benefit those that follow. **"**The key is to do it faster than others because you learn and therefore the next innovation comes sooner as well," he argues.

Figure 6.2: Key technical innovations

Estimated average operating costs for copper mines in western world 1900–2009 (2009 $/tonne ore)



Includes transportation, smelting & refining and marketing costs
Source: MinEx Consulting based on data from Brook Hunt, CRU Historical reports, MinEx Consulting Estimates (1900–1974)

Generally innovation has been employed on a "needs must" basis at times of low commodity prices or in the face of declining ore grades or other challenges. There is also less risk involved when testing innovative ideas and new technology in a downturn. The most recent technological breakthrough was the development in the 1960s and 1970s of the leach-solvent extraction-electrowinning (SX-EW) process that contributed to a dramatic turnaround in the fate of the declining US mining industry from the mid-1980s onwards, points out BHP's president of Minerals Americas, Daniel Malchuk (see figure 6.2). "Necessity makes creativity flourish," he says. Anglo American's CEO Copper, Hennie Faul, agrees: "It is a travesty to waste a burning platform opportunity in the downturn to change mindsets". Anglo American has continued its focus on innovation and technology throughout the recent lower commodity price cycle, he adds.

But this does not necessarily mean reinventing the wheel — miners can learn from more innovative industries such as manufacturing. Collahuasi chief executive Jorge Gómez found inspiration in Mexican cement company Cemex, which replicates the Swiss clockwork precision of its Monterrey plant in its acquisitions worldwide. Likewise the oil and gas industry faces far more complex challenges than mining, but it has developed an ecosystem of small tech entrepreneurial companies that have resolved specific issues, he says.

Although some technological research will be proprietary, there are also opportunities for the industry to share risk and costs through collaboration. For example, in Australia collaboration ecosystems have been proliferating, according to a report by Deloitte (Monitor Deloitte, Innovation in Mining, Australia 2016). Mining companies present issues in open industry forums and suppliers and other mining representatives brainstorm how to solve it. Companies also taking part in "hackathons" involving a large number of people meeting to engage in intense, collaborative software development to rapidly resolve specific problems. The country's miners are also working with others through mining innovation hubs in which multiple stakeholders connect and collaborate, according to Deloitte. "We've found a local industry well-placed to lead the world in mining innovation," it said.

> "The key is to innovate faster than others because you learn and the next innovation comes sooner as well."
>
> **ARNAUD SOIRAT**
> CEO COPPER & DIAMONDS, RIO TINTO

Industry leaders agree that innovation and new technology will be indispensable to maintaining the industry's competitiveness over time. Ageing operations, deepening mines and declining grades are a continuous pressure on mining companies' costs. "There needs to be a step-change in the use of technology to improve performance," says BHP's Malchuk. Mindsets need to change as happened when the US mining industry began widely employing SX-EW technology in the mid-1980s, he says. Potential innovations include digitalisation

to enhance decision making, and application of technology in unlocking reserves such as the more elusive leaching of primary sulphides, according to Malchuk. The operations of tomorrow will be very different to what we see today, he believes.

But innovation and technology are not only required to drive productivity improvements. They are also needed to lift the industry's safety, environmental, and community performance as well as to address society's demand for "green" products. As professional services firm PwC warns, in today's world of rapid change, mining companies need to be ready for what the future holds rather than fall victim to it (PwC, *We need to talk*, 2017). Unless it embraces technological change, the mining industry risks being overtaken by new entrants from the tech sector or consumer brands, and losing any remnant of public trust, it says.

Small advances are being made in this direction. Examples are the large-scale use of thickened tailings pioneered at Antofagasta's Centinela operation; improved efforts at recycling water as well as the increasing use of desalination plants for process water across the industry; and energy efficiencies and the greater of use of renewable energy.

But the desired transformational change remains elusive. One of the few mining companies to have a technical director on its board, Anglo American is aiming high with its FutureSmart Mining™ programme. The extraction of ore without explosive blasting, the elimination of fresh water from mining processes and the transformation of data into predictive intelligence are some of its aspirations. "It has not yet delivered the step-changes that we need but it has initiated projects and started to change mindsets," says Faul.

Innovation and new technology have the potential to be a transformational source of improved productivity and value creation. Miners must grasp the nettle to remain competitive, while also responding to society's clamour for improved safety, environmental performance and "green" products.

LESSON SEVEN

Beware of growth at any cost

Bigger is not always better

The 2000s supercycle heralded an unprecedented wave of mining mergers and acquisitions (M&A) and organic growth projects both at existing mines (brownfield) as well as at fresh sites (greenfield). Capital investment in new developments reached a peak of over US$80 billion in 2012, retreating by close to two-thirds of that level today (Deloitte, Mining capital projects, 2018).

Meanwhile, in the first decade of the century, mining M&A reached a total of over 11,000 transactions worth close to a total of US$785 billion, more than any other global industry sector (PwC, Global Mining Deals 2010, 2011 , see figure 7.1). The pace of M&A only began falling away in 2012.

Capital investments at the top of the cycle were distorted by inflated market capitalisations and project valuations that would tumble along with commodity prices. In addition, intense rivalry for project development capabilities and inputs, the pipe dream of continued high commodity prices, and poor project controls (see Lessons 8 & 9) caused development costs to escalate. Awash with money, mining companies did not pay sufficient attention to detail. In many cases companies paid over-the-odds to buy or develop new assets that did not meet payback estimates when the market turned. The frenzy to invest in growth at any cost squeezed cash flows by bringing on less profitable production, swelled debt levels and placed many mining companies in severe financial difficulties (see Lesson 3 on balance sheet discipline).

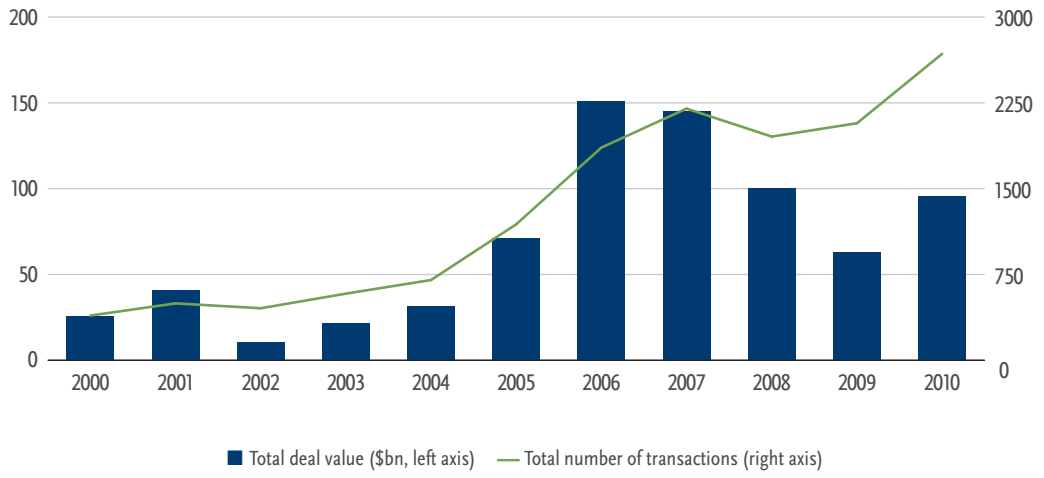
The period was characterised by bombastic rivalry among the major diversifieds, typified by a series of mega-deals that never happened: BHP's bid for Rio Tinto (2007), Vale's wish to buy Xstrata (2008), Xstrata's offer for Anglo American (2009) and Glencore's for Rio Tinto (2014). Among the gold majors, a proposed tie-up between Barrick Gold and Newmont Mining collapsed in 2014. With

hindsight, the failure of these ambitions may have been fortuitous; they reflect a time that was marked by a lack of austerity and a sense of omnipotence.

Mining companies need to exercise caution and patience when selecting acquisition targets, says Jerry Jiao, chief executive of MMG. A lot of time and expense goes into evaluating deals that may eventually be dropped if criteria are not met, such as MMG's pursuit of Equinox Minerals in 2011, according to Jiao. "We will simply not do the deal for the sake of the deal. We do the deal for the sake of value," he emphasises. The company is better able to take this patient, long-term approach to acquisitions because its major shareholder (with approximately 74% of equity), China Minmetals, supports the strategy, he says. "If you've got a major shareholder pushing for deals, it would be difficult."

Figure 7.1: Global mining M&A volume and aggregate value

Value in US$bn, volume in # transactions



Source: PwC, Global Mining Deals, 2011, based on data from Capital IQ; PwC analysis

"The industry become fixated with size as the response to optimising investments. The pursuit of gigantism was seen as the right answer," says Iván Arriagada, chief executive of Antofagasta. "There's a huge lesson here." The financial risks were not properly assessed and long-term commodity prices were not modelled with cyclical effects, according to Arriagada. Typically, commodity price curves showed a more promising future than they had done in the past, leading all companies to hurry and invest. The lowest price scenario needs to be adequately defined and projects require stress tests with a wide range of assumptions and conditions, he says.

During the supercycle, companies' assumptions of long-term prices — used to justify 20-year mining investments — were overly influenced by recent spot metal prices. There was a very high correlation between changes to long-term price expectations and the move in spot metal prices from 2004 to 2010, says Douglas Upton, an investment analyst with Capital Group. Metals that saw the biggest spot price increases also saw the biggest changes to long-term price estimates. "The single biggest price signal the industry should have paid attention to was the unit cost of adding capacity, because it became so high that it was ridiculous," says Upton. Projects were being developed on the assumption of US$3.50/lb copper and US$100/t iron ore, more than three times higher than the price used for the previous 30 years.

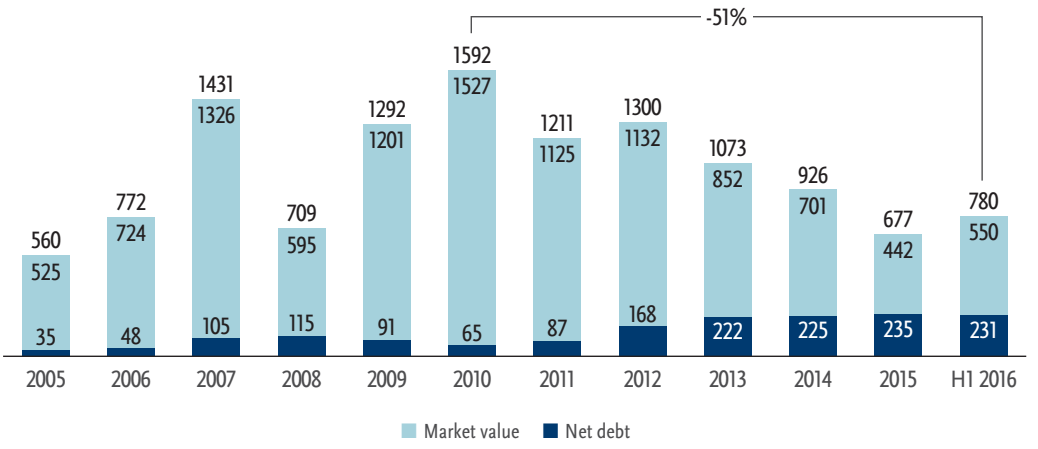
Unit costs spiralled out of control fast, partly because companies justified their long-term price decks based on the incentive price — the commodity price required for projects to provide a reasonable internal rate of return (IRR). It was a circular argument because the incentive price itself results from the initial price assumptions that go into scoping projects, explains Upton. By using a high commodity price assumption in the scoping study, projects ended up with higher capex, higher strip ratios, and lower ore grades included in the mine plan. "A high price assumption in scoping studies drives you to put every piece of dirt into the reserve or resource statement," he says. "There were lots of mistakes here."

"Culturally, we like to build, do things, and invest. There's a culture of the bigger the better to capture economies of scale."

DIEGO HERNÁNDEZ
PRESIDENT, SONAMI

Figure 7.2: Market value and net debt for mining companies

US$bn



Source: BCG, Restoring Investor Confidence, 2016 based on data from S&P Capital IQ; annual reports; BCG analysis

The tendency of mining engineers to overlook the industry's cyclical nature during the supercycle was due to a lack of discipline but also "a natural desire in mining companies to build stuff," comments Upton.

"Culturally, we like to build, do things, and invest," agrees Diego Hernández, president of Sonami. "There's a culture of the bigger the better to capture economies of scale." It is natural for project development people to try and make a mediocre project look good and then include as much "blue sky" potential as possible, he says. Furthermore, there is a tendency to prefer projects with lower operational costs even if it means increased capital investment upfront: "Nobody thinks that the investment is high and it might be preferable to reduce the risk and increase operational costs."

BHP's head of Minerals Americas, Daniel Malchuk, also believes that some focus was lost on the volume versus value analysis. "It was thought that volume always implied value but it's not always the case," he says. Volume sometimes signifies value because you produce more and dilute your costs. However, investors and analysts were very critical of how mining companies consistently favoured volume at the expense of capital, leaving shareholders empty-handed, according to Malchuk. Too often companies reinvested capital in over-priced projects at the height of the cycle instead of returning cash to investors (see Lesson 3), he says.

Although the optimum size of a mining project is usually large, the risk of capital intensity can be handled by sequencing expansions through a series of smaller projects, in much the same way as the oil and gas industry. "For mining companies, a phased approach to the larger investments could spread the risk," advises Deloitte (2018). During the supercycle no-one questioned the sense of approving large projects but with lower prices sequencing them has become a more attractive option, agrees Hernández.

Another lesson learned as a consequence of the supercycle was the advantage of doing joint ventures, or sharing infrastructure, to mitigate risk, according to Hernández. Typically, working with partners is regarded as complicated but large companies are now more open to associations, he says. In the Americas, notable examples of major joint ventures are the Cerrejón coal mine in Colombia, the Antamina copper-zinc mine in Peru and the Escondida and Collahuasi copper mines in Chile.

> "The single biggest price signal the industry should have paid attention to was the unit cost of adding capacity, because it became so high that it was ridiculous."
>
> **DOUGLAS UPTON**
> INVESTMENT ANALYST,
> CAPITAL GROUP

Newer examples include the NuevaUnión copper-gold-molybdenum project in Chile's Atacama Region, which combines Goldcorp's El Morro and Teck's Relincho projects. The association aims to reduce costs and the project's environmental footprint by sharing a concentrator, transmission line, roads, and a port as well as the option of a desalination plant for process water. Likewise, Goldcorp has formed the Norte Abierto joint venture with Barrick Gold to leverage potential synergies for the companies' Cerro Casale and Caspiche projects in the Maricunga gold belt, also in Atacama Region. Over the border in Argentina, in 2017 Barrick sold 50% of its Veladero gold mine to China's Shandong Gold and in July 2018 the two companies announced an agreement to consider opportunities to work together on acquisitions or potential asset sales.

"We will simply not do the deal for the sake of the deal. We do the deal for the sake of value."

JERRY JIAO
CHIEF EXECUTIVE, MMG

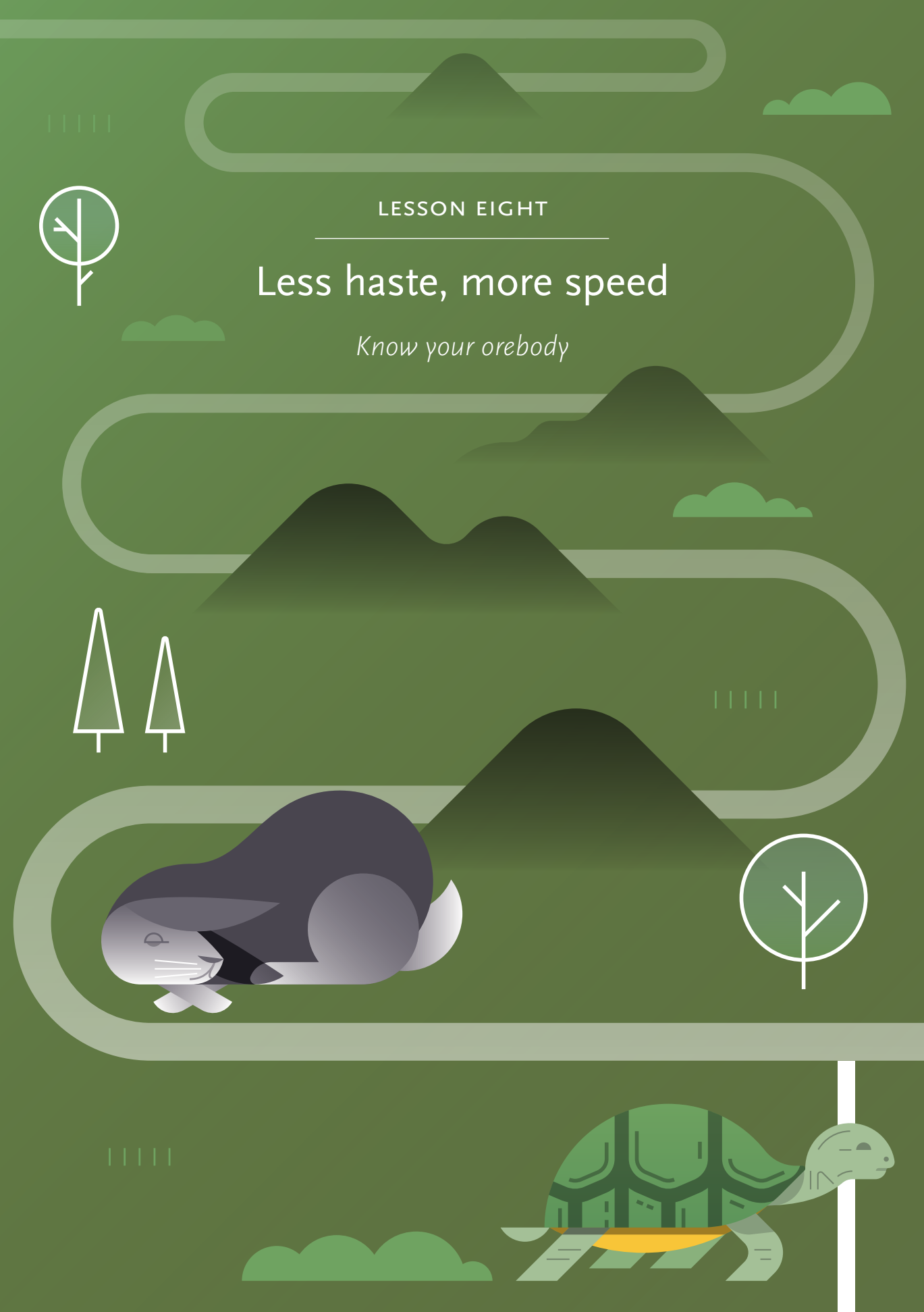
But more could be done. In terms of shared infrastructure, the mining industry lags behind other business sectors such as oil and gas, airlines, and even the highly secretive pharmaceutical industries. Railway lines, pipelines, shipping lines, and desalination plants are just some of the areas where companies could reduce financial risk — and environmental footprints — by sharing installations. "We are pretty slow on that," says Anglo American's CEO of Copper, Hennie Faul.

As commodity markets move into a more positive pricing environment, the lesson is for mining companies to maintain a steady hand and not get swept away by grandiose ideas.

LESSON EIGHT

Less haste, more speed

Know your orebody



The rush to increase production of metals during the 2004 to 2014 supercycle exacerbated the poor development and execution of projects. A 2015 study of 78 projects by Export Development Canada (EDC) noted that while capital cost overruns were endemic in the industry, "significant" under-budgeting was a recent trend.

Average capital cost overruns soared to more than 40% in the period 2006–2010 from around 12% in 2001–2005, according to EDC, which provides funding for development projects (see figures 8.1 and 8.2). The study found that average capital cost overruns for mega-projects (capex of more than US$2 billion) over a 20-year period were the worst, at over 60%.

When broken down by location, the EDC study found that projects developed in Australia had the highest average overruns, followed by Europe and South America respectively (see figure 8.3). Another variable with a significant impact was the location of project sponsors: on average companies headquartered in Asia, followed by South America, saw their project costs soar the most. North America achieved the best results in terms of both project location and sponsor headquarters, according to EDC. By commodity, nickel, copper and gold projects were the worst three offenders respectively.

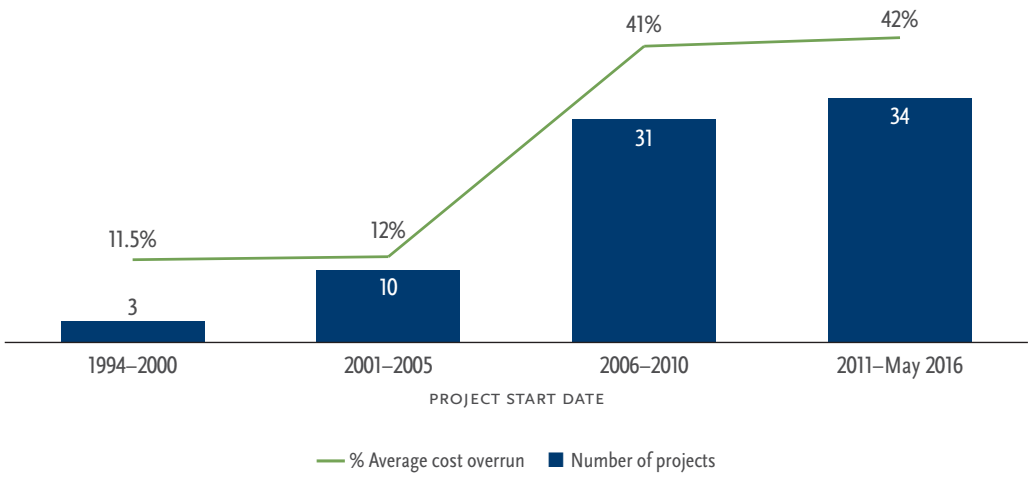
"The first step is to understand the ore body."

KENNETH PICKERING
INDEPENDENT MINING CONSULTANT AND COMPANY DIRECTOR

A 2015 Tetra Tech survey of 49 industry leaders on the causes of capital cost overruns highlights how a lack of thorough planning at the start of projects contributes to poor budgeting and scheduling. It named the top five reasons as 1) aggressive and unrealistic schedules; 2) lack of properly defined testwork/defined design criteria/work scope; 3) client pressure to minimise the initial capital requirements; 4) under-estimation or insufficient critical data from early engineering studies; and 5) over-estimated accuracy/under-estimated contingency.

Figure 8.1: Average cost overruns in global mining projects

1994–May 2016



Source: Export Development Canada, Capital Cost Overrun and Operational Performance in Mining Industry, May 2016

Often it was the attempt to fast-track projects that actually slowed them up. "The impulse, the idea, the anxiety of boards to be able to capture high prices is not compatible with the orderly execution of projects," says Codelco chief executive Nelson Pizarro. It usually requires 10 to 12 years for a new project to be implemented and this was not congruent with companies' overly optimistic plans to bring on new production fast to secure high commodity prices, he says.

Projects were poorly scoped and under-engineered, says the chief executive of Anglo American, Mark Cutifani. There was also insufficient partnering and risk sharing, he says: "There needs to be more capital discipline and risk management in the approval of projects, with proper toll-gating processes." And, he adds, boards need to be far harder on company executives, insisting on more robust evaluation and measurement of projects. More time must also be spent on strategy and understanding the market before projects are sanctioned, according to Cutifani.

"The greatest probability of error — an almost irreparable error — is the difficulty of adequately representing all the geological alterations contained in an orebody."

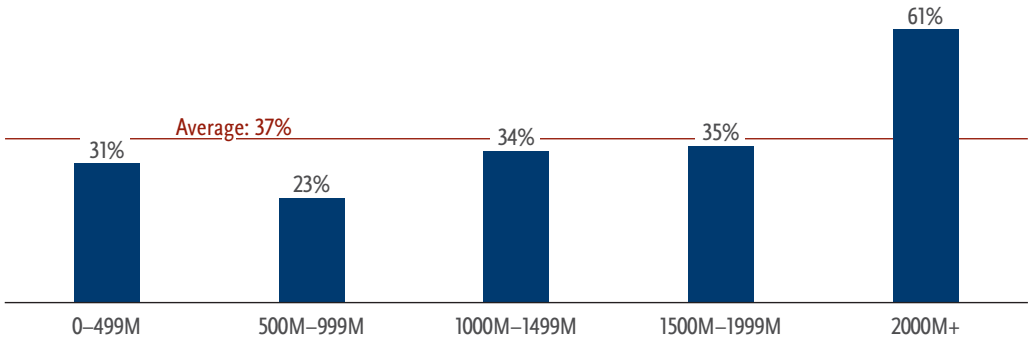
NELSON PIZARRO
CHIEF EXECUTIVE, CODELCO

In the case of Chile, Caserones (JX Nippon Mining & Metals), Sierra Gorda (KGHM) and Antucoya (Antofagasta) were three marginal projects that were aggressively advanced prematurely. The Antucoya copper project came online over a year late after the project was suspended to control escalating costs and then suffered commissioning and ramp-up issues. The Sierra Gorda project has also tussled with overruns and commissioning issues, especially related to molybdenum production where the problem was exacerbated by crumbling prices for the metal.

Meanwhile at Caserones, an extremely low-grade copper and molybdenum project located at an altitude of over 4,200 metres above sea level, buoyant commodity prices caused investors (see Lesson 1 on cycles) to overlook the project's challenging physical and geological conditions. Capital costs rocketed from an estimated US$2 billion in 2010, when construction was approved, to US$4.2 billion in 2014 when construction was completed. The project had still not met design capacity of 150,000 tonnes per annum by the end of 2017.

Figure 8.2: Cost overruns and project size in global mining projects

1994–May 2016 , project size in US$



Source: Export Development Canada, Capital Cost Overrun and Operational Performance in Mining Industry, May 2016

"You win and lose projects with front-end engineering and planning."

RICHARD ADKERSON
CHIEF EXECUTIVE,
FREEPORT-MCMORAN

The mine, majority-owned by Japan's top smelter JX Nippon Mining & Metals, together with Mitsui Mining & Smelting Company, has cost its owners large impairment charges.

"The project was conceived as a fast-track project and the focus of the construction strategy was to complete construction as soon as possible," recalls Pizarro, who led the Caserones project at the time. In addition, capital costs escalated because the project was built at the peak of high prices when there was avid competition for inputs, engineering and construction services and labour.

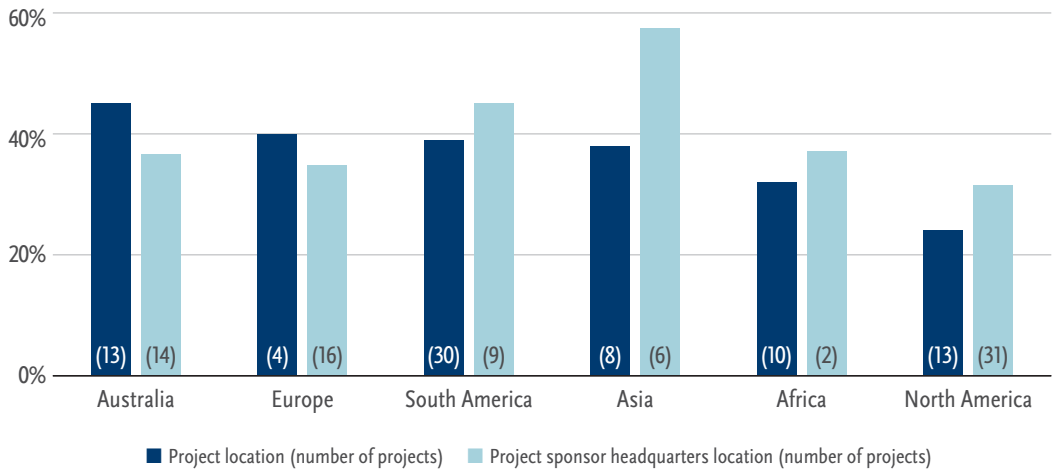
Many other mining projects faced similar issues. Boards across the world had to weigh up the costs of stopping, closing and rehabilitating projects versus continuing construction as costs escalated followed by an unexpected collapse in commodity prices. The decision is particularly complex when taking into account the large upfront investments required by the industry to start projects.

Industry leaders agree that the success of project development lies in spending enough time in the early stages of evaluation. "You win and lose projects with front-end engineering and planning," says Richard Adkerson, chief executive of Freeport-McMoRan, which successfully completed a US$4.5 billion expansion at its Cerro Verde copper mine in Peru in 2015 on time and budget. In addition, the company had a very experienced construction team, he adds.

The first step is to understand the orebody, advises Kenneth Pickering, a mining veteran with over 40 years in the industry. Together with strong project management, this is the foundation for developing a mine and plant that will generate cash flow and provide payback on the investment, he says. Without the correct metallurgical testing, plants will not run as planned. In addition, companies must build strong community relations from the outset of project planning, during execution and the long-term operational

Figure 8.3: Cost overruns by location

1994–May 2016, Cost overrun %. Number of projects in parentheses



Source: Export Development Canada, Capital Cost Overrun and Operational Performance in Mining Industry, May 2016

phase, as well as having in place a skilled, motivated workforce. "If the relationship with the community and workforce is not proactive and positive, the mining venture will never achieve its potential," says Pickering.

It takes a number of years to characterise a mineral resource in sufficient detail to effectively determine the design criteria that will eventually be transformed into processing plants, says Pizarro. "The greatest probability of error — an almost irreparable error — is the difficulty of adequately representing all the geological alterations contained in an orebody," he says. The importance of designing installations capable of processing all the types of mineralisation found in an orebody cannot be understated. The prefeasibility stage — which establishes the design criteria — is especially relevant, the Codelco chief stresses.

Figure 8.4: Top five contributing factors for cost overruns

Survey of 49 industry representatives in 2015

1	Aggressive and unrealistic schedules
2	Lack of properly developed testwork/defined design criteria/work scope
3	Client pressure to minimise the initial capital requirements
4	Underestimation or insufficient critical data from early engineering studies
5	Overestimated accuracy/underestimated contingency

Source: Tetra Tech

It is also necessary to have board members with sufficient project development expertise to counterbalance the emotional involvement of operators in their projects. Pizarro warns that some operators will make projects look enticing by presenting over-optimistic operational costs. Internal processes to tollgate project approvals should be audited by third parties and will act as a brake against over-hasty decision-making, he says.

In the excitement to fast-track projects, there was a tendency in the supercycle to overlap early works with detailed engineering. This should be avoided, says Pizarro: "Spend the time you need to spend in having an almost complete development of engineering: don't jump the gun."

LESSON NINE

Build in-house expertise

Don't lose control of projects

The significant capital cost overruns and project start-up delays during the supercycle generated a debate on the engineering, procurement, and construction management (EPCM) model that was widely used to deliver projects.

In the past, the main mining companies had much larger in-house mine engineering teams, recollects Douglas Upton, a long-standing analyst at Capital Group who was analysing commodity markets for Australia's WMC Resources in the 1990s. "These people were life-long employees and really good," he says. When there were no in-house projects to develop, they kept themselves busy and tuned-up with outsourced projects from smaller miners. This began to change after the 1997 Asian crisis, when companies drastically cut engineering and geological capabilities after a long period of low profitability. When the supercycle kicked off in the early 2000s, mining companies lacked the projects and the engineers to address increased demand, says Upton.

In tandem, EPCM contractors took advantage of the supercycle and gained ground in the development of organic growth projects. They transitioned from providing services on a person-hour basis, plus a fee, to actively participating in the mining business by offering "improved" services such as reducing capital costs in feasibility studies or fast-tracking projects, explains Diego Hernández, another mining industry veteran and currently president of Chilean mining association Sonami.

> "Companies that got on the bandwagon in time generated a lot of value ... The problem is when you venture out too late in the cycle."
>
> **DANIEL MALCHUK**
> PRESIDENT, MINERALS AMERICAS, BHP

But due to the scarcity of resources, EPCM businesses often had to resort to sub-contracting work to other companies and taking on inexperienced people. “B teams” replaced the “A teams” that had been promised to develop projects. This was not just problematic for mining companies but also inconvenient to other business sectors that lost employees to the better-paying mining industry.

As a consequence, while mining companies’ supervision of project development weakened, poorer skill-sets, higher project costs, and delayed schedules were ushered in. This was exacerbated by a trend towards approving projects with engineering of less than 20% complete during the heady 2000s decade, rather than a more responsible level of over 60%.

Another drawback to the EPCM model was the way it was used in the supercycle to fast-track construction, says Codelco chief executive Nelson Pizarro. The race to rapidly bring projects online led to a tendency to overlap project development stages such as early works with assembly and construction, he explains. The lack of detailed engineering that accompanied this practice ultimately led to project delays as contractors would complain that they had insufficient technical data to complete the work. Overtime would then be approved to offset hold-ups, with resulting drops in productivity. In addition, argues Pizarro, technical briefs for construction must contain sufficiently precise unit price estimates that are aligned with contingency levels. There is no better investment of time than ensuring that engineering levels are advanced before construction is triggered, he says.

> “The industry needs to return to how it was before and have an owner’s team that is responsible for doing the project.”
>
> **DIEGO HERNÁNDEZ**
> PRESIDENT, SONAMI

"Companies should be the way they used to be and spend a bit of money on R&D and have a few engineers that know and follow developments."

DOUGLAS UPTON
INVESTMENT ANALYST,
CAPITAL GROUP

The increased use of EPCM contractors was partly an inevitable result of the supercycle that was marked by insufficient resources to develop projects, says BHP's Daniel Malchuk. Mining companies such as BHP adopted a strategy to effectively secure those resources by creating project development hubs in joint ventures with EPCM companies. The company's projects were more expensive but the payback was rapid due to high commodity prices. **"**Companies that got on the bandwagon in time generated a lot of value ... The problem is when you venture out too late in the cycle, a mistake made by many companies," he says.

Nonetheless, there is unanimous agreement among interviewees that, irrespective of the project development model used, it is vital for companies to strengthen their in-house project capabilities. BHP recently reverted to a system used previously, that of a more empowered owner's team, according to Malchuk. In addition, the business has refocused on completing a greater level of engineering prior to commencing construction.

"The industry needs to return to how it was before and have an owner's team that is responsible for doing the project, contracting engineering and construction companies, but retaining control," says Hernández. In addition, mining companies must keep control over the development of environmental impact studies, he says. There is a risk that these are carried out by consultants who may be environmental experts but lack experience of mining operations. The danger is that overly onerous or restrictive commitments will be included in the lengthy studies, not always reviewed in their entirety by commissioning companies. Likewise, this paucity of mining know-how can lead consultants to include figures for operating capacity that do not take into account the different processing rates for soft and hard ores. "There are a lot of lessons here," underlines Hernández.

US copper miner Freeport-McMoRan relies on its own experienced in-house construction team, says chief executive Richard Adkerson. "We don't just turn over our projects to an outside contractor." The company draws on experience and expertise from across its business to strengthen projects as they are being developed. "There's communication and input into how decisions are made, as opposed to having oversight and reviewing a decision," he explains.

This will be music to the ears of Capital Group's Upton. "I know I am showing my age, but I just wish companies would be the way they used to be and spend a bit of money on R&D and have a few engineers that know and follow developments," he says. This would not only improve project development but also give a welcome boost to the industry's need to hasten the adoption of innovation and technology.

LESSON TEN

Hire fewer but better people

Use contractors to provide flexibility

One of the consequences of the commodities supercycle was a significant increase in direct and indirect employment in the mining industry as companies sought to boost production from current operations or new projects.

The levels of salaries, bonuses, and benefits also soared. This was driven by heated competition among companies to attract and retain employees and successful wage negotiations by unions making the most of the price bonanza. Many companies focused on setting competitive bonuses rather than using them effectively as a performance management tool. Unions rightly negotiated for the best outcome for workers, and companies were reluctant to provoke a strike while commodity prices were high. As in other areas, a lack of austerity pervaded human resources management.

"Mistakes were made in the excessive use of contractors and in a type of labour relations that distorted the reality of the mining industry," says Codelco chief executive Nelson Pizarro. Tough adjustments were required in the ensuing downturn to ensure the sustainability of the industry.

Nonetheless, the inflated pay packages obtained during the supercycle still weigh heavily on the sector's productivity. In Chile, for example, between 2003 and the peak of direct mining employment in 2014, employment rose by 150% but had dropped back by only 15% by the end of 2017 (see figure 10.1).

Antofagasta chief executive Iván Arriagada agrees that the issue of salary inflation during the supercycle remains unresolved. The crux is to ensure that salary changes reflect sustainable productivity gains and that the structure of compensation provides the right incentives to pursue continuous improvement so that everyone wins, he says. There is no doubt that going forward automation will lead to decisive changes in the composition of the workforce and quite likely to fewer and more highly qualified people. This trend will probably shift

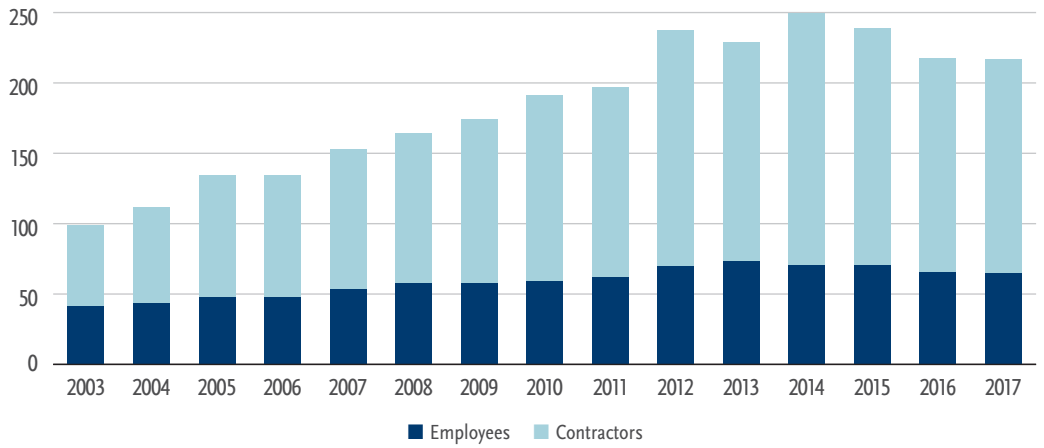
the centre away from the one-off bonus payments that are typically awarded in Chile when collective wage negotiations are completed, according to Arriagada.

Larger companies run talent development and retention programmes to keep the best people. Initiatives like these identify key professionals and critical skills — such as maintenance — and offer the right mix of training and incentives to attract and retain in-demand employees. Building a compelling company culture is also an important part of this strategy (see Lesson 11 on company culture).

Salaries and incentives — or annual bonuses — must be sustainable through the cycles, say industry leaders. "Permanent commitments cannot be assumed based on temporary variables," points out Pizarro. Incentives should be centred on productivity, sustainability and cost targets, rather than commodity prices, to preserve required efficiencies when prices are low, he advises. In addition, the right balance must be struck between meeting targets for production or material-moved, and sticking to scheduled maintenance

Figure 10.1: Direct mining employment in Chile

Head count in thousands (000)



Source: Cochilco

programmes, says Malchuk. The use of integrated key performance indicators (KPIs) will foster collaboration and also contribute to increased discipline and productivity.

Traditionally mining has drawn skills from a narrow pool of engineering and business graduates (PwC, *We need to talk about the future of mining*, 2017). The industry tends to be resistant to change and slow to accept innovation (see Lesson 6 on innovation). These characteristics do not make it the most exciting sector to work in, especially during cyclical downturns, making it harder to attract talent. Likewise, its self-sufficient, over-confident culture is often reluctant to learn from outsiders or other industries. For example, long-standing Japanese expertise in metallurgy and manufacturing initially faced resistance at JX Nippon Mining and Metals' Caserones mine in Chile.

This tendency needs to be broken if mining companies are to employ the best people to respond to a rapidly changing, environmentally aware, increasingly digital world. "One of the biggest mindset shifts that must occur in the mining industry is the one around talent and diversity," says PwC. New recruits need to have an entrepreneurial mindset and start-up mentality, it argues. This will feed into greater diversity of thinking that will help the industry to solve long-standing problems such as water use, land access, environmental impact, safety and carbon emissions, it argues. A more diverse workforce will also be crucial for spurring the industry to embrace technology and innovation.

The lack of diversity is reflected by the poor representation of women in mining. One 2013 study estimated that women made up around 10% of the workforce on average globally (PwC and Women in Mining UK, *Mining for Talent* 2013). Many major mining companies are now actively addressing the gender balance. For example, BHP has committed publicly to women making up half of their workforce by 2025. Rio Tinto aims for 50% of its graduate intake to be women.

Another area of focus is to improve female representation in leadership roles. The leaders of Antofagasta, Anglo American and BHP have signed up to the 30% Club goal of achieving a minimum 30% female representation on boards and executive committees (ExCo).

"Diversity means drawing from the widest available talent pool of both men and women, across nationalities and cultures, and fully leveraging their complementary skills and attributes once they are in the organisation."

MARK CUTIFANI
CHIEF EXECUTIVE,
ANGLO AMERICAN

Meanwhile, the Hampton-Alexander Review has set a 33% target for women on FTSE 350 company boards and in senior management positions (ExCo and their direct reports) by 2020. In 2017, on average FTSE 100 companies achieved 25.2% in senior management positions and 27.7% on boards. The performance of mining companies in the FTSE 100 is shown in figure 10.2.

"We need to be more diverse as an industry," agrees the chief executive of Anglo American, Mark Cutifani. This is particularly important in today's complex and competitive world, in which the best minds and inclusive leadership are essential to finding innovative and sustainable solutions to business challenges, he says. "In practice, this means drawing from the widest available talent pool of both men and women, across nationalities and cultures, and fully leveraging their complementary skills and attributes once they are in the organisation," asserts Cutifani.

MMG chief executive Jerry Jiao is proud of the strength that diversity brings to the company, which has been built on long-term Chinese planning to secure access to key commodities and Australian mining know-how. "From the very beginning, we differentiated by combining East and West," he says. Investment capital and strong assets alone do not build an organisation: employees must have the right skill-sets, according to Jiao. "It's not just having the money, it's really the issue of having the capability to develop and operate the project," he stresses, referring to the company's Las Bambas copper project in Peru.

Meanwhile, headcounts can be kept down and productivity improved with leaner organisational structures. There is particular scope for this in Chile, according to the National Productivity Commission's (CNP) 2017 report on the mining sector. It found that the country's large mines had six to eight hierarchical layers compared to four to five in international best-practice mines. "This is evidence of a command and control-based management culture, which reduces initiative, restricts autonomy, dilutes responsibility between layers, and increases costs," the report says.

Figure 10.2: Women on boards and in leadership positions in FTSE 100 mining companies

Place in FTSE 100 ranking and % of women

Rank	Company	Women on boards (%)	Combined ExCo and direct reports (%)
14	Randgold Resources	37.5	20.6
47	BHP	27.3	31.7
76	Anglo American	23.1	15.3
89	Rio Tinto	18.2	24.7
93	Antofagasta	18.2	12.3
95	Fresnillo	16.7	10.7
97	Glencore	12.5	15.6

■ Already at 33% or more women ■ On target at 27% or more women □ Below target

Source: Hampton-Alexander Review, FTSE Women Leaders, November 2017

Antofagasta adopted a new organisational model when commodity prices began to decline, enabling the company to be better positioned for foreseen future challenges, says Arriagada. Higher levels of standardisation and a much more operationally focused business model led to a leaner, simpler, and more integrated organisation. Together with this, functional and support activities — such as finance, reporting, and human resources — were centralised and simplified to improve efficiencies to support the business.

"Regardless of the copper price, the benefits are obvious in terms of obtaining synergies, standardising, implementing best practice and developing a talent pool at group rather than site level," he says. Importantly, it allows operations to focus on sustainable production, costs, safety and continuous improvement.

Contractors can bring in new methodologies rapidly and are useful for critical interventions, believes Arriagada. However, using third parties to reduce costs is a short-term solution, he says. Companies should maintain control over critical activities, especially core business areas such as mine planning and resource development. Key operating activities, maintenance planning, reliability, and continuous improvements can be differentiating factors or comparative advantages, according to the Antofagasta chief. For example, the company internalised critical planning processes at Los Pelambres mine to increase in-house capabilities and controls. In the area of maintenance, this has allowed the operation to move from a mainly reactive maintenance programme to one that is predictive and proactive, and much more reliant on condition monitoring, he says.

"Mistakes were made in the excessive use of contractors and in a type of labour relations that distorted the reality of the mining industry."

NELSON PIZARRO
CHIEF EXECUTIVE, CODELCO

Industry leaders agree that the use of contractors must be based on whether they add value and be decided on a case-by-case basis. "The use of third parties is all about what is the most effective and efficient way of doing the business," says Arnaud Soirat, CEO of Rio Tinto's Copper & Diamonds business.

Contractors can provide mining companies with the flexibility to temporarily increase personnel quickly in bull markets, says Pizarro: "One has to have a variable cost structure that can be cut when the cycle is over." Contractors will charge high fees but it will be profitable for the mining business at the peak of the cycle and not perpetuated on the payroll when commodity prices turn. "Payrolls need to be kept as tight as possible," he concludes.

LESSON ELEVEN

Make your company worth working for in good times and bad

Build pride in your company

An attractive company culture helps companies retain employees in periods of high demand for skilled workers. It can also smooth the way to implement transformational change in more difficult times. Strong core values, diversity, greater autonomy, and inspiring leadership are just some of the critical ingredients.

"Workers must identify with their companies, they must feel pride and not only well-paid," says Codelco chief executive Nelson Pizarro. People do not only take jobs based on economic incentives; a company's reputation, organisational structure, sustainability policies, and innovation are also important, he says.

"It is necessary for companies to create a deeper link with employees so they feel important for the company and that their work is highly valued," argues the chief executive of Collahuasi, Jorge Gómez. Employees should have more autonomy and a sense of pride in where they work and what they do, he says.

Increased training is an obvious tool to help develop more self-sufficient, responsible, and satisfied workers. Talent development programmes should take this a step further by identifying and empowering workers who can be promoted to supervisory and even management roles after training. Experience from international best-practice mines indicates that this boosts productivity (Comisión Nacional de Productividad, 2017).

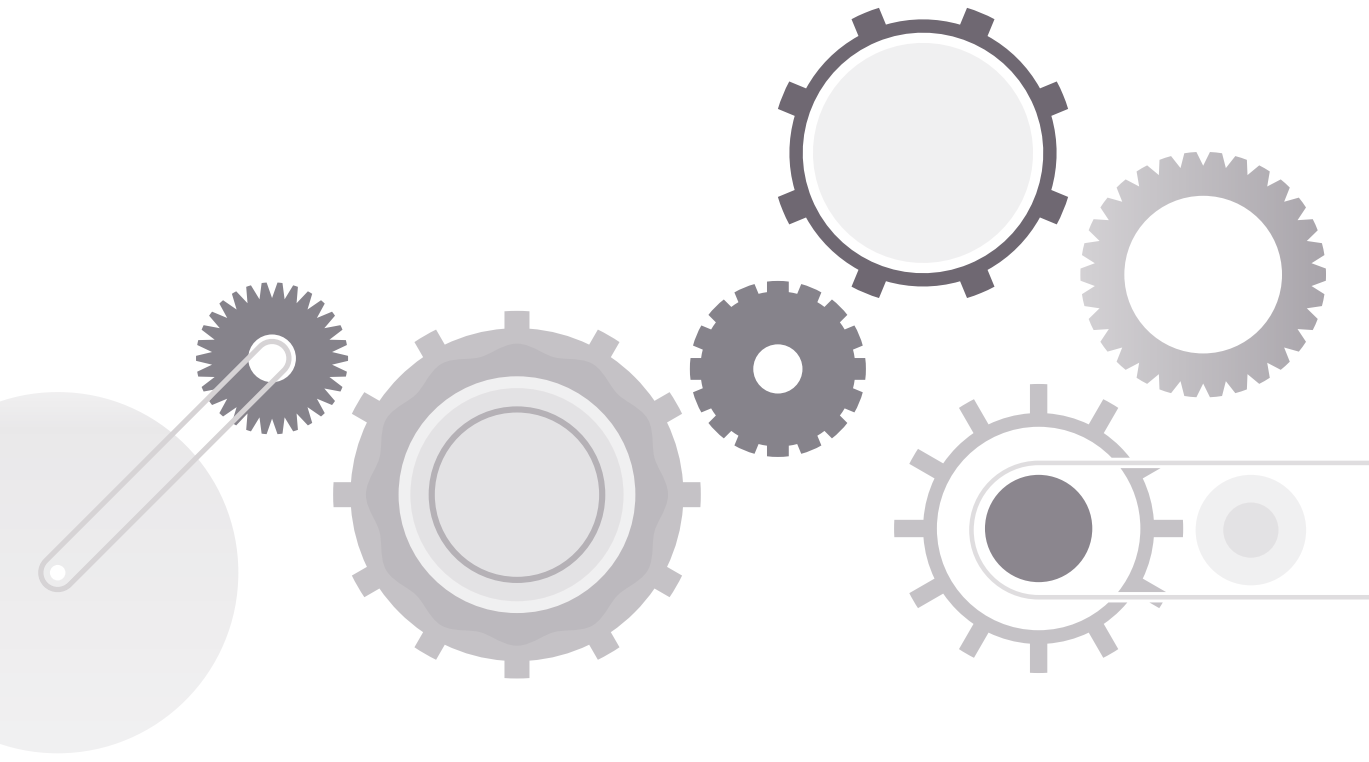
A company's values can deliver a real competitive advantage when reflected in concrete actions and the workplace culture and environment (see also Lesson 12 on sustainability). Brand loyalty and role validation help retain employees, while lifting individual and overall performance. "Like many people working here, I was attracted to Rio Tinto because of the way it is guided by its values," says Arnaud Soirat, CEO of Rio Tinto's Copper & Diamonds business. "They are its strength through good times and bad."

“The common purpose of improving safety made sense to everyone and on this basis we created a more holistic, more altruistic purpose that finally united the capacities, effort and interest of all.”

JORGE GÓMEZ
CHIEF EXECUTIVE,
COLLAHUASI

A company's values and culture, once embedded in the operational model, are the best defence to avoid getting swept away by a commodity supercycle, says the chief executive of Antofagasta, Iván Arriagada. The company used the commodity downturn as an opportunity to revisit its corporate values, initiating a six-month, bottom-up process in which employees participated to develop a joint charter.

Antofagasta is also working to develop a more compelling value proposition in response to concerns raised in employee surveys. "We have a purpose. We are committed to mining for a sustainable world and the development of the country [Chile] and we work to ethical standards," he explains. This provides the framework for employees to understand the reason behind management's focus on increased productivity and stimulates step-change, he says.



"Workers must identify with their companies, they must feel pride and not only well-paid."

NELSON PIZARRO
CHIEF EXECUTIVE, CODELCO

An inspiring leadership that sets the tone and manifests values that are in tune with society's standards builds employee rapport, says Arriagada. Nowadays leaders must focus not only on economic targets but also on the business impacts on the environment and communities, he adds. Leaders need to listen more, ask for solutions, and acknowledge what they don't know. The company is also building leadership skills at all organisational levels to foster autonomy, best practice, and ultimately ownership of roles.

When company morale is low — perhaps as a result of low commodity prices or a high-profile event that causes reputational damage — it is indisputable that leaders must reinforce positive attributes and identify a common goal around which employees can work together, advises Gómez. When he took the helm of Collahuasi in 2012, the organisation was suffering from low self-esteem due to high management turnover and poor production and safety performance.

Under his leadership, Collahuasi was able to turn things around by aligning employees around the common purpose of improving safety. “It made sense to everyone and on this basis we created a more holistic, more altruistic purpose that finally united the capacities, effort and interest of all,” he recalls.

A healthy corporate culture — underpinned by strong values and communication — allows companies to develop a positive relationship with employees and unions. This will help stem the flight of employees to the competition. It also offers an opportunity to discuss with employees the cyclical nature of the mining business, paving the way for flexible pay packages. Ultimately, this may reduce conflicts in commodity price downturns and lead to sharing the profits more equitably during upswings.

LESSON TWELVE

Embed sustainable development in the business model

And engage openly and effectively with stakeholders

The 2000s supercycle, and the consequent surge of new projects, focused public attention on both the opportunities and negative impacts associated with the mining sector. Social media and greater access to information accentuated the trend. The period was marked both by widespread opposition to new mining projects and intensified demands for a bigger share in the benefits of mining, as well as greater environmental protection and increased community consultation. Tighter regulation and increased mining levies followed.

The revival of commodity prices after a five-year slump is likely to trigger renewed visibility of and interest in the industry. EY notes that as commodity prices and profits improve, government and regulators, especially in developing countries, have increased efforts to obtain greater local participation in mining profits (EY, *Top 10 business risks facing mining and metals 2017–2018*, 2017). EY now rates regulatory risk, new to its ranking, as the fifth most important risk for mining companies (see figure 6.2 in Lesson 6).

Meanwhile, the social licence to operate is ranked by EY as the seventh top business risk in 2017–2018 (from fourth in 2016). Social conflict around mines — due to factors including involuntary resettlement, traditional land rights, and environmental impacts — continues to hold up new projects, it says. Examples include Newmont's Conga project in Peru, Tahoe Resources' Escobal mine in Guatemala and Gabriel Resources' Rosia Montana project in Romania.

Figure 12.1: Safety performance (2012–2017)

International Council on Mining and Metals (ICMM) member companies

Year	Total recordable fatalities	Fatality frequency rate	TRI (total recordable injuries)	TRI frequency rate	Total hours worked
2012	90	0.033	13895	5.07	2,738,579,590
2013	91	0.035	11636	4.52	2,571,500,557
2014	56	0.024	10455	4.5	2,324,525,784
2015	60	0.027	10494	4.7	2,231,437,832
2016	63	0.032	8445	4.26	1,981,148,588
2017	51	0.027	7515	3.94	1,906,708,433

Source: ICMM

Mining companies that embrace sustainable development across the organisation, from the board of directors to mine site workers, will be better equipped to successfully navigate these challenges. This includes strong health and safety, environment, and community performances alongside effective, participatory stakeholder engagement.

"We cannot survive without sustainability front of mind; it's a key focus in all our thinking and a major part of Anglo American's DNA," says Hennie Faul, CEO of Anglo American's copper business. Maintaining trust and effective relationships with all stakeholders — including communities, governments, employees and investors — is crucial, he says. Faul believes that the focus on sustainability will become even more indispensable as social demands continue to clash with major companies across all business sectors.

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

OUR COMMON FUTURE: REPORT OF THE WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT (1987, ALSO KNOWN AS THE BRUNDTLAND REPORT)

"We have to understand intimately the unique social, cultural, political and economic aspects of every place we operate if we want long-term success," says Arnaud Soirat, CEO of Copper & Diamonds at Rio Tinto. The need to develop projects in a responsible way in terms of engagement with employees, communities and governments is a key lesson from the supercycle, he says. Companies should nurture a good reputation worldwide rather than defining jurisdictions by the ease of their operating environment. The challenges are the same everywhere but manifest themselves in different ways and at different times, Soirat believes. "We operate according to our values wherever we work."

The mining industry has made significant advances over the past 20 years in terms of how it engages with stakeholders and the importance it places on sustainable development, says Jorge Gómez, the chief executive of Collahuasi. Financial results are no longer seen in isolation from long-term business sustainability, he notes. However, this understanding still needs to filter down to employees who do not work directly in sustainable development or public relations, such as engineers or mine workers, according to Gómez. "It is a concept that is still being internalised," he says.

Mining companies worldwide have stepped up their game on sustainability, including large investments in community initiatives. Major mining companies have set ambitious safety and health and environment targets, such as water and energy efficiencies, among others. In the case of safety, the industry has not managed to eliminate fatalities, but notable overall improvements form part of its drive to do so (see figures 12.1 and 12.2).

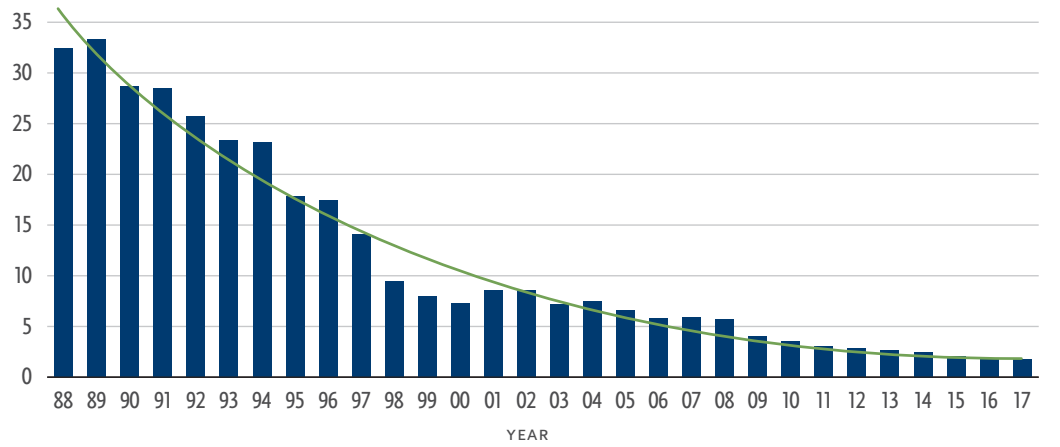
When commodity prices are strong, the industry can make a significant contribution in terms of jobs and fiscal revenues in countries endowed with plentiful mineral resources. Yet, despite improved sustainability performance, it remains an unpopular industry. Gómez suggests that the public perception of Chilean mining companies might benefit from a greater presence on the Santiago Stock Exchange with exposure to institutional investors, such as pension funds, mutual funds, and insurance companies in which many Chileans invest.

When possible, training local people rather than housing workers from elsewhere in mining camps would significantly contribute to the economic development of mining areas, proposes Sonami's Diego Hernández. It would involve a lot of training and be a challenge for companies but it could help build local support for the industry, he believes.

Mining companies should also maintain control over environmental impact studies (EIS), says Hernández. An overdependence on consultants may lead to community conflicts and project delays, he says. For example, engineering consultants may fail to factor in community considerations by favouring a more economic water source close to the mine but in the middle of a local community, rather than a more expensive option that may well be further away but is less likely to cause opposition.

Figure 12.2: Chile accident frequency rates

Accidents per million person-hours



Source: Sernageomin

“We cannot survive without sustainability front of mind; it’s a key focus in all our thinking and a major part of Anglo American’s DNA.”

HENNIE FAUL
CEO COPPER,
ANGLO AMERICAN

Traditionally mining companies adopted a paternalistic attitude towards communities, often deciding and developing mine infrastructure and social investments without their input. "There are lessons learned here," says Hernández, citing communities that became stiff opponents to projects after failures to engage effectively with them, for example on access roads. "Communities need to be part of the process; it's not for us to decide what they need," he says.

In addition to active participation, community relations should be built on medium- and long-term agreements, says Codelco chief executive Nelson Pizarro. "The main lesson is that short-term agreements with communities, usually driven by immediate economic and material needs, don't work." Meanwhile, EY notes too the importance of a shift from pursuing a reactive and compensation model of social investment to one that is more strategic and collaborative.

Freeport-McMoRan's investment in Arequipa's first wastewater collection plant as part of its expansion of its nearby Cerro Verde mine is a good example of how this can be done. In exchange for building the plant, the company is able to extract water for its project from the facility. But the spin-offs are equally important: the plant modernised Arequipa, Peru's second-largest city; cleaned up the local river by processing waste; restored the river's fish; and enhanced downstream agricultural industries. The company had previously financed a water treatment facility for the city. "We have lots of support from the local community, which is unusual in Peru," says company chief executive Richard Adkerson.

High-price commodity cycles will last for longer in future due to the increased amount of time it takes to get permits, hindering the industry's ability to respond efficiently to demand growth, says Hernández at Sonami. Chile's environmental regulatory framework

evolved in piecemeal fashion leading to duplication of permits among agencies and inefficiencies. Today, companies are required to obtain some 800 permits, compared to 600 in the past. Hernández believes that it is essential that the country establishes a more effective regulatory framework, which incorporates in a structured manner the view of the impacted communities. "It's not about being more relaxed but more efficient," he says.

Industry leaders agree that an aggravating issue in Chile is the lack of finite deadlines governing the permitting process. "The worst is not knowing how long it will take," says BHP's president of Minerals Americas, Daniel Malchuk.

There are lessons here for governments too. Countries with burdensome bureaucracy, or levels of tax, will inhibit investment, ultimately hitting their fiscal revenues. "If countries do not fix the red tape coming out of a downturn, they may miss the next upturn," says Anglo American's Faul.

> "Communities need to be part of the process; it's not for us to decide what they need."
>
> **DIEGO HERNÁNDEZ**
> PRESIDENT SONAMI

But it is also imperative for companies to keep up with the times. For example, today's consumers increasingly want to buy products that meet certain performance, health, and sustainability criteria. As their interest in product traceability grows, there will be greater pressure on the mining industry to produce so-called "green" metals.

Some mining companies are seeking to address these concerns. Codelco is working towards developing "green copper" produced with certifiable high environmental standards, non-conventional renewable energies (NCREs) and a low carbon footprint, as well as evidence of forward-thinking gender and community integration policies.

Anglo American's FutureSmart Mining™ innovation initiative is pushing towards the prospect of an industry where modern mines can safely extract ore without explosive blasting, water, or producing waste. BHP, a standard bearer for climate change, has committed to being carbon neutral from 2050.

More recently, diversified mining company Rio Tinto caught the attention of green investors by its exit from coal, completed in early 2018. The company took a strong position on climate change in the early 1990s with its promotion of clean aluminium and a low carbon aluminium footprint, says Soirat. "It's bigger than getting out of coal, it's more about doing business in a way that shows our contribution to society over the next generation," he says. "We can be part of the solution rather than part of the problem."

CONCLUSION

The key is to remain disciplined in all things

At the best of times and the worst of times

The early 2000s commodities cycle of high prices ushered in an era of growth and opportunities for mining companies and mining countries alike. However, the unprecedented scale of Chinese demand and the resulting boom in commodity prices caused the industry to react in an often irrational and over-exuberant manner.

There was a tendency for boards and senior management to take decisions based on an emotional desire to grow rather than for cool-headed, technically sound reasons, exacerbated by investor pressure to do so. It was as if all involved had forgotten that mining is a cyclical industry in which periods of high prices are inevitably followed by low ones.

When the crash came, an overstretched industry suddenly found itself in dire straits. Companies sold off good assets, put operations on ice, slashed headcounts, and suspended dividend payments to survive. The industry's lack of discipline and inadequate oversight was a common theme in our frank and extended conversations with industry leaders recalling the heady years of the 2004–2014 price bonanza.

Strong governance (Lessons 1–4)

Navigating commodity price volatility is an integral part of the mining business. Although mining companies cannot individually control — or predict with any accuracy — commodity price cycles, better governance, strategic direction, and risk management can shield them from boom and bust scenarios.

The key is not to over-react when prices are high by overspending or by drastically cutting back when prices fall. Where possible, companies should be counter-cyclical, reserving cash for investment opportunities when commodity prices are low, costs have fallen back, and well-qualified human resources are freed-up.

Decisions based on short-term considerations when prices are high can have untold consequences as mistakes cannot be easily rectified. The main decisions must be based on robust intelligence and a long-term outlook of at least 10 years; indeed some companies prefer a 15- to 20-year horizon. For this purpose, companies must establish — and be guided by — a rigorous set of long-term price assumptions that are not distorted by commodity price spikes.

Strong and accountable leadership is required to resist the pressure from internal stakeholders, investors, banks and analysts to make short-term gains at the cost of long-term pain. Disciplined and detailed scrutiny of capital allocation should prioritise sustaining capital, debt repayment, rewarding investors, and funding growth projects in that order of priority. Conservative balance sheets are preferable in an industry that is subject to extreme commodity price swings and large sustaining capital requirements. Decisions must be supported by responsible risk management protocols.

Experience matters. Boards need to be diverse and contain critical eyes from other industries. That said, it remains paramount that boards include directors who have a deep understanding of mining's specific characteristics: its cyclical nature, minerals resources, and project development, operating cash cost structures, and the key margin points of the industry's complex value chain. And in these times of disruptive change, a technologically savvy director is also a plus.

Operational excellence and innovation (Lessons 5–6)

Competitive, low-cost operations that can withstand commodity price downturns are the bread and butter of world-class mining companies. This objective can be achieved only by a disciplined and unswerving focus on productivity and cost control. The industry should never let ambitious growth plans distract it from this fundamental principle. Stable and adroit operational leadership will help meet this goal.

The importance of adding value rather than volume is another key takeaway, together with a focus on an operation's overall efficiencies instead of isolated improvements to bottlenecks. The sector needs to

learn from the manufacturing industry and treat mining as a continuous production line rather than a series of batch processes. This approach includes sticking to scheduled maintenance shutdowns.

Transformational innovation and technological change is required for the mining industry to offset ageing operations, declining ore grades, and deeper mines. Automation, predictive data and analytics will enhance productivity and help the industry to manage the ebb and flow of commodity cycles. These are also priorities for companies that want to keep pace with societal demands for safer, cleaner, greener mines with fewer environmental impacts.

Disciplined growth (Lessons 7–9)

It is critical not to overpay either for acquisitions or for organic development projects. The unit price of adding capacity must always be aligned with robust long-term price decks and realistic operating cost assumptions. Likewise, companies need to weigh up more closely the benefits of higher capital costs versus lower operating costs; bigger is not always better. It is worth exploring options to share infrastructure with other mining companies — or even other industries — to reduce large upfront capital investments.

Many mistakes were made in the haste to bring new supply on line as soon as possible. Orebodies must be adequately understood and tested, engineering advanced and host communities fully consulted and supportive before projects are approved. Strict toll-gating mechanisms must be in place. Strong in-house project development capacities and know-how are essential for companies to manage and maintain control over organic growth options.

Creating strong, diverse and innovative organisations (Lessons 10–11)

During the supercycle the industry used human resources as an easily applicable patch to support increased production. Headcounts rose rapidly, as did salaries, benefits, and bonuses. The consequences are still being felt today in terms of productivity and cost control.

Remuneration packages must be sustainable throughout the cycles. This approach involves maintaining slim payrolls of well-qualified people; contractors can provide flexibility and be brought in to respond to commodity cycle upturns. Incentives need to be geared towards improving productivity and curbing costs and include individual as well as collective indicators. The provision of centralised service functions can lead to leaner organisational structures, and fewer hierarchical levels will create a more autonomous and satisfied workforce.

In future it is imperative that the mining industry draws skills from a more diverse talent pool if it is to embrace innovation, improve productivity, and address deep-rooted issues such as tailings management, water and energy consumption, and stronger relations with local communities. This will feed into more appealing and stronger company cultures that will help to attract and retain talent.

The combination of inspiring, visible senior leaders and fostering leadership skills at all levels will develop more committed and able employees. Staff will feel more affinity to companies whose core values reflect societal standards. Once embedded into operational models, values and standards can protect companies against overexuberance during periods of strong metal prices.

Sustainable development (Lesson 12)

The decade-long period of high prices in the early 2000s shone the spotlight on the mining sector, generating closer scrutiny of its overall performance, including safety, environmental and interaction with local stakeholders. Companies that neglected early, effective and meaningful engagement and consultation with host communities saw their organic growth projects stall.

Effective sustainable development performance must be led with commitment from the top and understood and implemented at all organisational levels. Companies must retain control over fundamental sustainability issues and not farm out these tasks to consultants. Community relations must be based on mutually beneficial, strategic and collaborative partnerships that incorporate their active involvement from the start.

The mining sector's sustainability performance has advanced significantly over the past few decades but society continues to raise the bar. The challenge for mining companies is to keep up with increased societal pressure for higher safety, environmental, consultation, and human rights standards. The way forward is to make sustainable development a core capability from the board down, set challenging sustainability performance targets, embrace diversity, and seek innovation and technological solutions to resolve key sectoral and societal issues.

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Mining for Value: Industry Leaders Disclose Lessons Learned from the Supercycle

Published by Spencer Stuart and Centro de Estudios del Cobre y La Minería (CESCO)

The supercycle that gripped the mining industry during the early years of the twenty-first century was unparalleled in its speed, length and intensity. When boom finally turned to bust, many companies were psychologically unprepared and financially overexposed. Mining for Value *examines what went wrong. It offers key insights from senior figures who experienced the cycle at first hand, and supports the next generation of leaders as they seek to build a more robust, diverse and sustainable industry for the future.*

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