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Catalyzing competitiveness

Where investment happens and why

Authors
Anna Kortis
Jan Mischke
Chris Bradley
Sylvain Johansson
Shubham Singhal
Olivier Bus
Camillo Lamanna

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At a glance

- **Global geopolitical shifts call for a new cartography of competitiveness.** In a debate often characterized by vague calls for "cutting red tape" or "structural reforms," this research makes the case for using productive investment as a proxy for competitiveness and charts a detailed line-by-line map of what investments happen where and why.
- **Investment has stalled in Europe, shifted in the United States, and pulled away from the pack in China.** This divergence poses different challenges in each region. Europe will need to close its €800 billion annual investment gap, while the challenge in the United States is to increase investment in manufacturing to mitigate risks linked to import dependencies. Meanwhile, China is adding three times more productive assets each year than Europe and the United States combined, but capital returns are roughly 40 percent lower.
- **Levelized costs in Europe and the United States are generally at least 50 percent higher than in countries currently attracting the most investment.** In manufacturing industries, the gap between advanced economies and China is about 50 percent, driven primarily by higher wages that aren't matched by higher productivity. In R&D, the gap is closer to 300 percent, and time-to-market is an important driver. Energy and feedstock price differences further increase costs in Europe, especially in heavy industry. Policy choices factor in these costs, as implicit subsidies differ by as much as eight times between regions while exchange rate effects widen the gap further.
- **Rebalancing investment would require a boost in productivity and innovation, specialization in less cost-sensitive industries, and policies to level the playing field.** A "what-if" analysis suggests that a 30 percent productivity boost, a convergence of equipment, energy, and materials costs, and an adoption of "China speed" in advanced economies would close 30 to 80 percent of the cost gap. Achieving a new balance would thus also require specialization in future-shaping and other critical industries; a revival of innovation and differentiation in countries with higher costs; and a rethink of industrial policy to address distortions in competition.

A new cartography of competitiveness

In a fracturing world, competitiveness has risen to the top of the agenda. Yet the debate is often muddled. The concept itself is poorly defined—the World Bank's competitiveness framework, for instance, identifies 1,200 contributing factors, and most economists prefer to focus on productivity, which avoids the fallacy of zero-sum thinking while highlighting what really drives prosperity.[1]
As global competition for investment, industrial capacity, and technology leadership intensifies, however, productive investment offers a practical way through: It serves as both a proxy for competitiveness and a gauge of productivity growth, warranting a central role in the debate.

Companies invest where they expect to be most successful, and when they feel confident that the framework conditions are in place to make an investment both possible and worthwhile. That makes investment a good measure of a country's *current* competitiveness. The proof of the pudding is in the eating, as the saying goes, and proof of a country's competitiveness is its ability to unlock domestic and attract global investment.

Investment also bolsters a country's productivity, prosperity, and *future* competitiveness—as well as its resilience against geopolitical shocks—by expanding its production and innovation capacity. Previous MGI research has found, for example, that tangible investments, like infrastructure and machinery, and intangible investments, like R&D and software, together account for up to 80 percent of productivity growth.[2] Economies with more productive capital per worker tend to be more productive because better equipment, systems, and technologies enable workers to create more value with their labor (Exhibit 1). Higher output in turn enables more investment to build and renew the productive capital base, creating a virtuous cycle.[3]

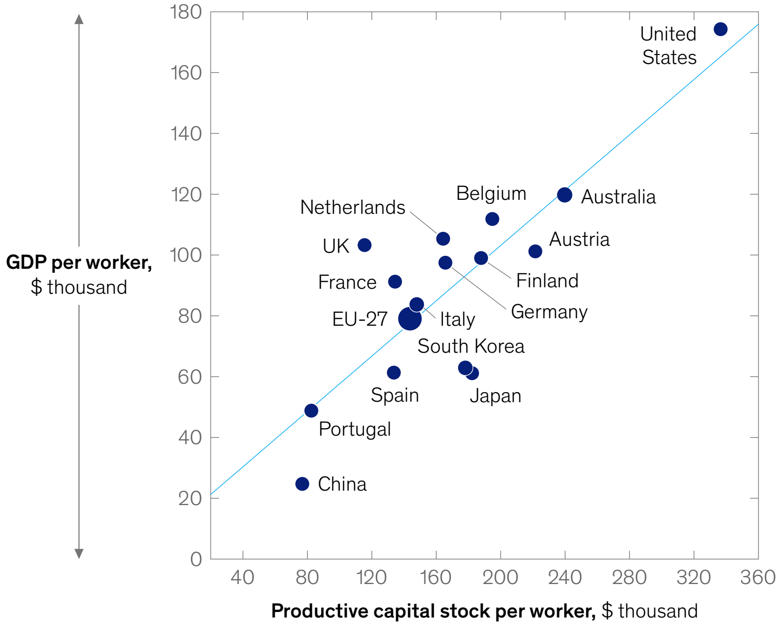
Advanced economies have long benefited from this virtuous cycle of rising investment and economic growth that supported their competitiveness. Over the past two decades, however, their investment engine has stalled. The slowdown is most pronounced in Europe, Japan, and South Korea, but, outside the AI-related investment boom, also is clearly visible in the United States.[4]

Recent geopolitical tensions have brought into sharp relief the lack of investment in industries that are now seen as strategic. This includes, for instance, energy infrastructure, semiconductor manufacturing, and, in Europe's case, also defense, digital industries, and AI technology.[5] Rising costs of capital and shifts from asset-light to asset-heavy business models add challenges, while the technological breakthroughs also create opportunities for a new investment revival.[6]

Exhibit 1

Investment drives prosperity, and vice versa.

GDP and productive capital stock per worker, 2024 or latest available, selected economies[1]



[1] 2024 market exchange rates. Includes commercial and industrial buildings. 2024 data used for the US, China, Australia, and the UK; 2023 data used for Japan and South Korea; 2022 data used for EU-27 and all EU countries.
Source: Australian Bureau of Statistics; Eurostat; Japan e-Stat; IMF; KOSIS (South Korea); Penn World Table; UK Office of National Statistics; US Bureau of Economic Analysis; World Bank; McKinsey Global Institute analysis

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In chapter 1 of this report, we analyze the shifting patterns of global investments over recent decades and what that reveals about competitiveness. In chapter 2, we turn to the microeconomics behind this shift, dissecting the line-by-line calculations underpinning virtually all real-world investment decisions for ten industries, including solar and nuclear electricity generation, chemicals and steelmaking, and manufacturing sites for batteries, semiconductors, and pharmaceuticals as well as colocation data centers, R&D projects in automotive, and biotech. Our microscope on business cases, and in particular levelized cost, draws on McKinsey's proprietary insights about decision-making in industries around the world and helps pinpoint what drives the divergence in investment between countries. In chapter 3, we explore what would be needed to restore investment competitiveness in regions and industries that are struggling to mobilize investment today at the level they are aiming for, bringing policy and business perspectives into full coherence.


Santa Fe

CHAPTER ONE

Global investment trajectories have diverged

Investment is tightly linked to productivity and competitiveness. Gross investment, including in intangibles like R&D, measures how much capital an industry in a particular country or region is attracting, which is a good measure of current competitiveness. If investors are willing to bet money on the industry in that location, it means the industry is competing successfully for resources there. Net investment, which adjusts for the maintenance and depreciation of aging assets, indicates whether an economy is adding to its productive and innovative capacity, which is a good measure of the future trajectory of competitiveness (see sidebar "How we measure investment[7]). Even if not all investments pan out, how much is invested by firms in an industry in a particular country today is a good directional gauge of how much that country will innovate and produce in the future.

Investment has stalled in Europe, pivoted in the United States, and pulled away in China

At market exchange rates, the United States is the world's largest economy, followed by China and the EU-27.[8] When it comes to investment, however, China is the biggest investor by any measure, followed by the United States. China's gross investment of $5.9 trillion a year exceeds the $5.1 trillion invested in the United States, and at a rate equal to more than 30 percent of GDP, almost twice that of the United States (Exhibit 2). The European Union, in comparison, invests only $3.1 trillion, a function of lower investment rates and lower GDP alike (see sidebar "How we measure investment").

Accounting for local price differences would increase China's lead further, because every dollar spent there translates into more cement poured or more researchers hired than in advanced economies. Using a typical purchasing power parity (PPP) index as a proxy, its gross productive investments of $5.9 trillion would convert to a whopping $11.9 trillion.[9] Using the same approach, the cost gap between the EU-27 and the United States narrows by half because $3.1 trillion in investment in Europe at market exchange rates increases to $4.5 trillion in PPP-adjusted terms.

The difference between the three regions is yet more pronounced in net terms. A large share of Europe's investment is required to replace aging and obsolete assets, pushing its productive investment rate from 16 percent of GDP in gross terms to just 2 percent in net terms, or about $400 billion of additions at market exchange rates. The US gross productive investment rate translates into net investments of $1 trillion, or about 4 percent of its GDP—more than twice as much as in Europe.

Sidebar

How we measure investment

Throughout this report, we focus on nonresidential or "productive" investment by the private and public sectors (exhibit). Productive investment is fixed investment in tangible and intangible assets such as infrastructure, nonresidential structures such as offices and factories, machinery and equipment, and intellectual property products such as software, databases, and R&D.[1] This is, of course, different from the concept of investment in finance, which concerns the purchase of equities, bonds, or other claims on the cash flow generated by the underlying real assets we consider here.

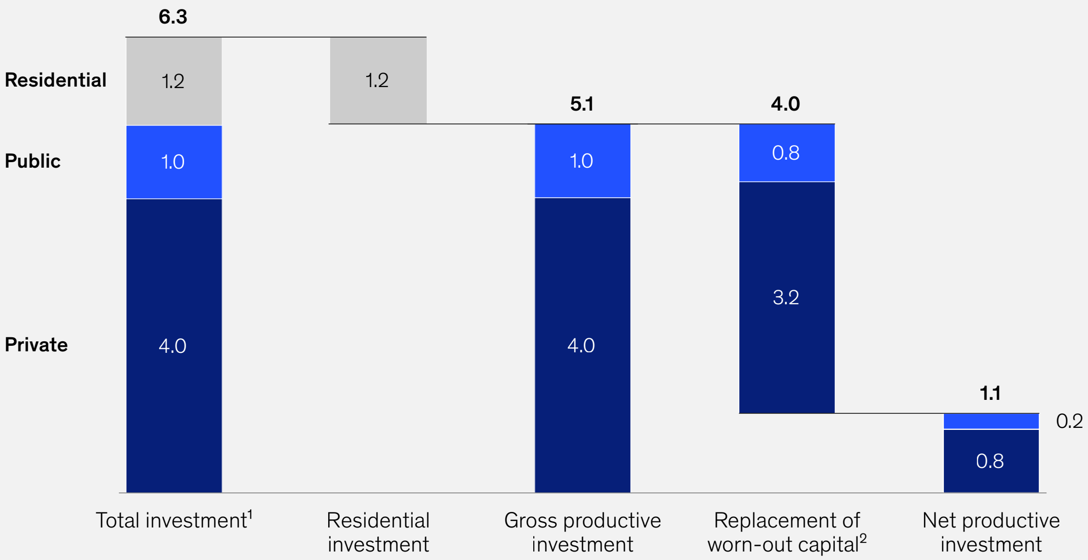
We examine productive investment in both gross and net terms. Gross investment is relevant as the most commonly reported metric, which measures how much capital investors are making available to an industry and so is a good measure of current competitiveness. Gross investment inevitably comes with newer capital, and newer capital is almost always more innovative. Moving from gross to net investment allows us to assess whether the investment is sufficient to replace worn-out capital and expand an economy's productive capacity, a good measure of future trends in competitiveness and the most relevant metric for productivity and GDP growth.

The US example in the following exhibit illustrates the distinction. Total US gross fixed investment was about $6.3 trillion in 2024. Of this, about $1.2 trillion was residential, leaving roughly $5.1 trillion of gross productive investment. But not all of that $5.1 trillion expanded the country's capital stock: About $4.0 trillion was used to replace worn-out or obsolete productive capital such as infrastructure, aging factories, and old technology. This left only about $1.0 trillion in net productive investment, the investment that adds new productive capacity to the economy. In other words, most US investment is used to maintain the existing capital base, while a much smaller share increases it.

Exhibit

In this report, we focus on 'productive' investments.

United States, 2024, $ trillion



Note: Figures may not sum precisely because of rounding.
[1] Total investment, or gross fixed capital formation (GFCF), measures spending on assets used in a production process for more than one year. It covers tangible assets such as machinery and buildings and intangible assets like software and R&D but excludes assets such as land and natural resources that are not the result of a production process.
[2] Replacement of worn-out-capital, or capital consumption (CC), is not reported by residential/non-residential in al countries. However, it is almost always available by sector. We therefore use the real estate sector as a proxy for residential dwellings.
Source: US Bureau of Economic Analysis, McKinsey Global Institute analysis

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[1] In national accounts, this measure is reported as gross fixed capital formation (GFCF), from which we subtract investments in residential real estate.

Sidebar (continued)

How we measure investment

While net investment is a useful measure, it is not perfect. Estimates of capital consumption depend on national accounting assumptions such as useful asset lives, which vary across countries and asset classes.

Our industry-level analyses are in gross terms, because capital consumption data is not reported consistently enough at the industry level across countries.

The historic macroeconomic data in this report are drawn from OECD databases for advanced economies and from national statistical agencies, supplemented with data from S&P Global Market Intelligence and Oxford Economics where official data are not available or are insufficiently granular. For example, S&P Global IHS Markit is used for China's capital consumption and India's investment figures, while Oxford Economics is used for the sectoral split of China's investment data. Most historical data are available until 2023 or 2024. The analysis of recent investments in the United States and China, in 2025 and 2026, uses official national statistics. Most data are reported in constant 2024 dollars, converted using 2024 market exchange rates.

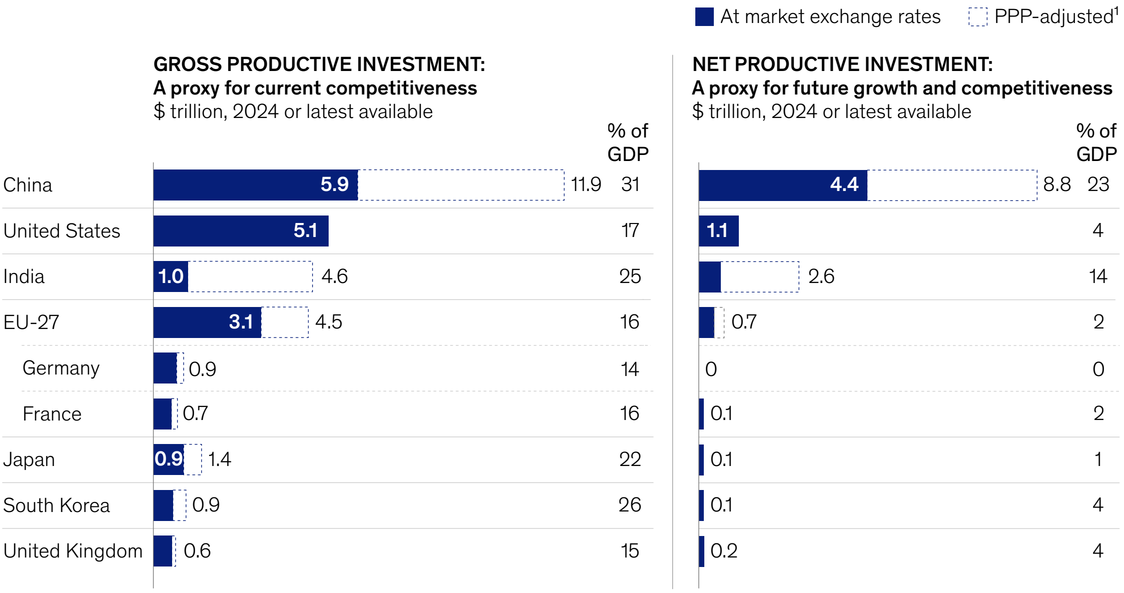
Since China is an emerging market with much less need to replace and maintain infrastructure and manufacturing equipment, the country's net productive investment rate is 23 percent of GDP, roughly six times higher than the US rate. That amounts to net investments of about $4.4 trillion at market exchange rates, or $8.8 trillion in PPP-adjusted terms. Thus, China adds between three and five times as much to its productive capital stock each year as the United States and Europe *combined*.[10]

Some difference in investment rates is to be expected, since China, like other emerging economies such as India, is still building the infrastructure, manufacturing capacity, and intangible capital that underpin urbanization and productivity growth. China's average productive capital stock per worker remains far below that of advanced economies, at roughly $80,000 compared with about $340,000 in the United States and $150,000 in Europe. Even so, the scale and persistence of China's net investment remain exceptional.[11] Moreover, averages are irrelevant when it comes to individual factories, which are state-of-the-art regardless of where they are built. Similarly, China's macroeconomic catch-up journey is of little consolation to, say, Western producers of solar panels or electric cars, given the rapid rise of new competitors investing and operating at a vast scale. The rapid growth in Chinese investment thus affects everyone.

Exhibit 2

China is the world's biggest investor by any measure.

Investment by economy



[1] Purchasing power parity (PPP) conversion factor, GDP (LCU per international $).
Source: OECD; S&P Global Market Intelligence; Eurostat; national statistical agencies; World Bank; McKinsey Global Institute analysis

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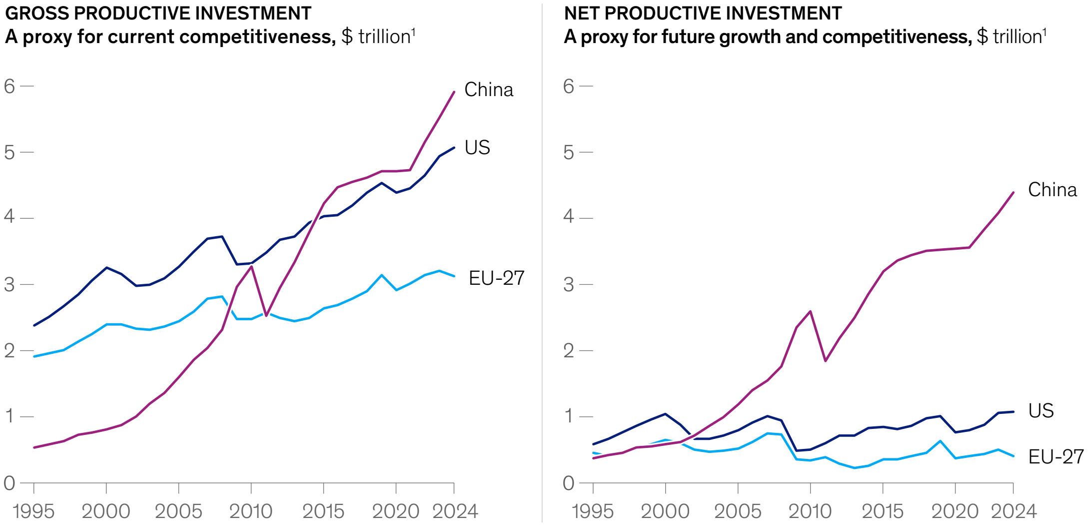
This disparity has emerged over the past three decades. In 1995, net productive investments were roughly equivalent in the three regions. Since then, having wrestled with the fallout of the global financial crisis, the Eurozone sovereign debt crisis, the COVID-19 pandemic, and different fiscal and monetary responses to these and other events, Europe has decreased its investments, the United States has stalled in the aggregate, and China has pulled away (Exhibit 3).

Exhibit 3

Regional investment patterns have diverged over the past three decades.



[1] Converted at 2024 market exchange rate.
Source: S&P Global Market Intelligence; China National Bureau of Statistics; Eurostat; US Bureau of Economic Affairs; McKinsey Global Institute analysis

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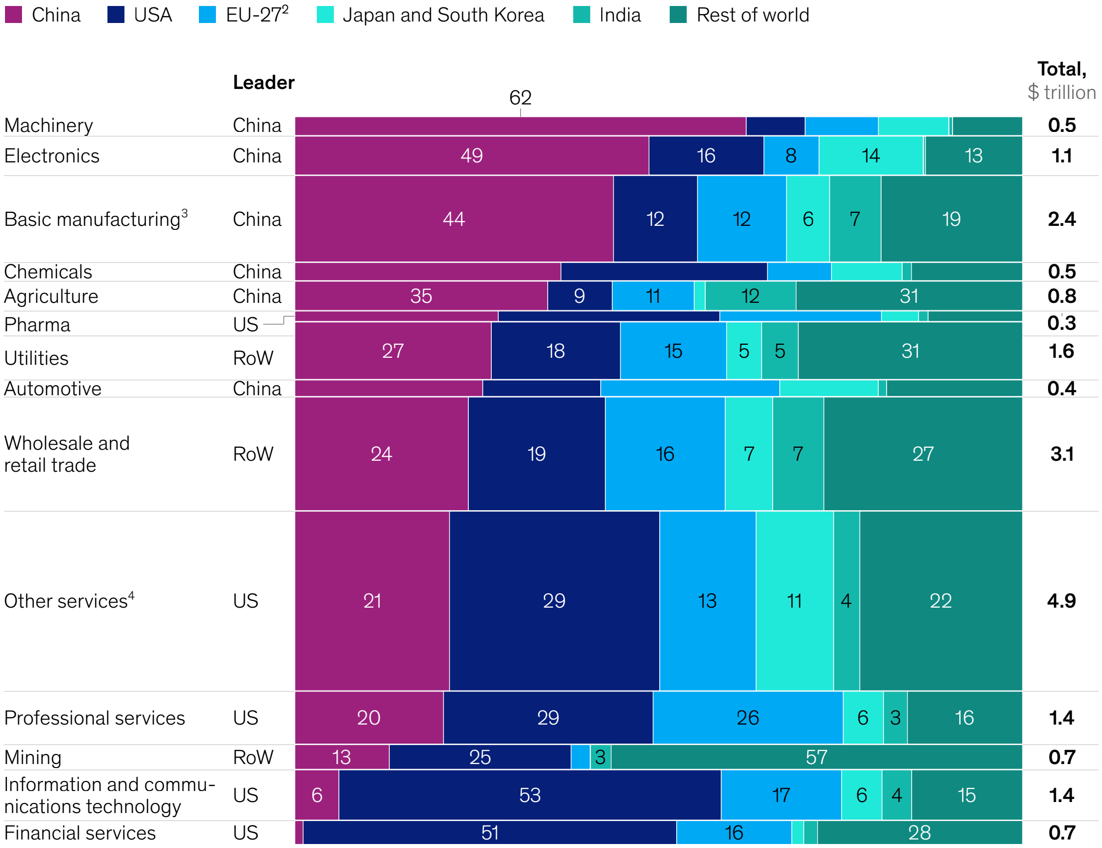
China: Staggering investment pace bolstered growth, but with diminishing returns
China's investment boom has bolstered its role in the global economy and is likely to expand it further. Across industries, China constitutes just under a fifth of global gross value added (GVA)—but more than a quarter of global productive investment. Roughly 63 cents of every dollar invested in the global machinery sector ends up in China.[12] In electronics industries such as batteries and semiconductors, China attracted 53 percent of all investment in 2024, while in basic manufacturing industries like steel, it won 41 percent (Exhibit 4).[13] Most of these investments are funded not by the global market but by the internally generated savings pool.

Exhibit 4

China's global investment share ranges from 1 percent in finance to 60 percent in machinery.

Global gross productive investment by economy and sector, 2024 average at market exchange rates, %[1]



Note: Construction and real estate are excluded as a proxy for excluding residential investment; in practice, some construction and real estate investment goes into commercial structures.

[1] Gross productive investment underrepresents the investment activity in China and other emerging economies as capex price levels are lower there.

[2] Croatia, Cyprus, and Malta are excluded due to missing data.

[3] Includes food and beverages, textiles, other transport equipment, petroleum products, wood products, furniture, jewelry, and other minor product categories.

[4] Includes public administration, education, human health and social work, arts and recreation, and other minor services.

Source: S&P Global Market Intelligence; OECD; Oxford Economics (China); McKinsey Global Institute analysis

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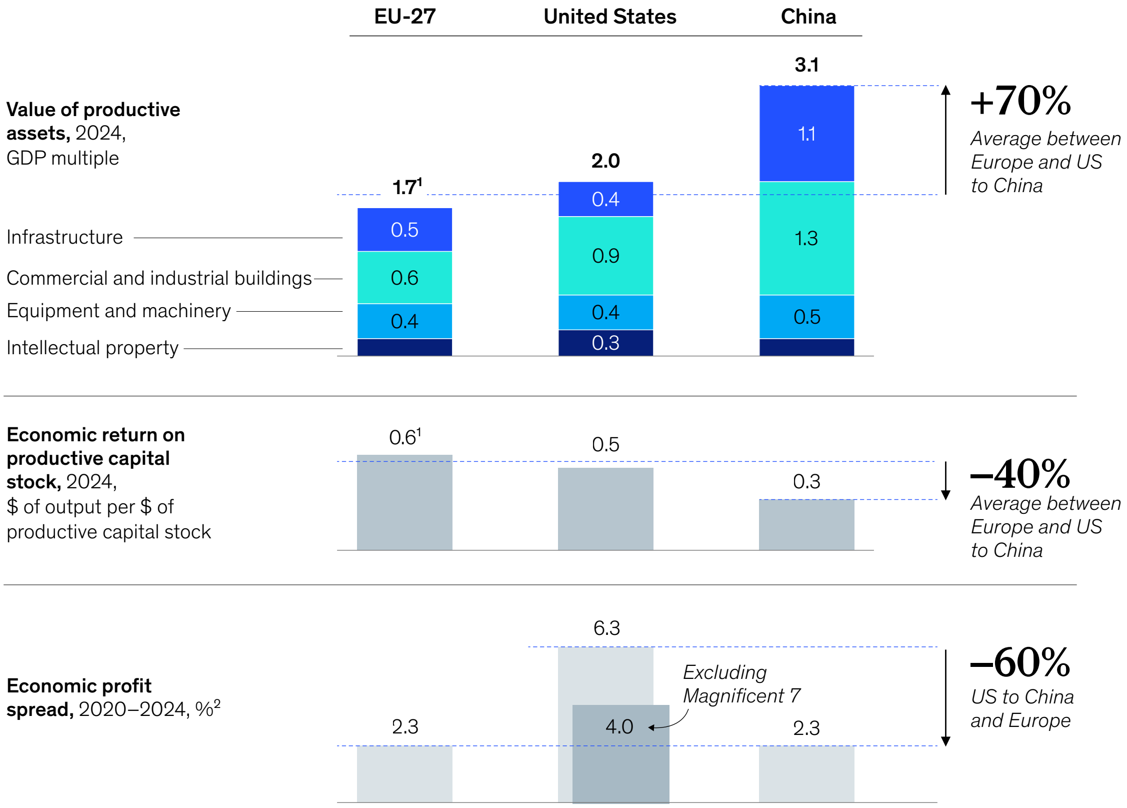
However, China's exceptional investment boom also has a downside: When capital accumulates faster than demand, low capital productivity and low returns result. Compared to the size of its economy, China now has 1.7 times the productive capital stock seen in the EU-27 or the United States, the result of more than twice as much capital deployed in infrastructure relative to GDP (Exhibit 5). This means that the value China extracts from its overall productive capital stock is 40 percent lower. This is partly because the country invested heavily in infrastructure and buildings, assets with lower direct returns in general, which has contributed to rising debt and weaker capital productivity.[14] But China also wrestles with excess capacity in many manufacturing sectors. For example, Chinese battery makers complain that they can no longer turn a profit.[15] In China, these diminishing returns on investment have been termed *neijuan*, or "involution," and the government has adopted policies to tackle it.[16]

Exhibit 5

China deploys 70 percent more capital per dollar of output than Europe and the United States.



[1] Eurozone only.
[2] Excluding businesses in energy and materials sectors. The economic profit spread is the return on invested capital (ROIC) minus weighted average cost of capital (WACC). A positive spread indicates value creation, as the returns generated exceed the cost of capital.
Source: CEIC; China National Bureau of Statistics; IMF; national statistical agencies; OECD; People's Bank of China; US Federal Reserve; McKinsey Value Intelligence Platform; McKinsey Global Institute analysis

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Total productive investment stopped growing in China in 2025.[17] But that headline hides big differences. Notably, China's investment in energy and utilities grew by almost 10 percent that year. Its investment in high-tech industries, particularly those in which China is directly challenging advanced economies, such as automotive, rail, aerospace, and shipping, grew roughly 15 percent year over year.[18]

Who is investing has shifted, too. From 2017 to 2021, much of China's investment growth was driven by private enterprises, which expanded investment by 7 percent each year compared to a 4 percent increase for state-owned companies. This pattern reversed from 2021 to 2024, as state-owned companies expanded their investment by 9 percent per year on average compared to only a 1 percent increase among private enterprises.[19] The increasing role of state-owned companies indicates that it may be becoming harder for private companies to find investment cases that add up.

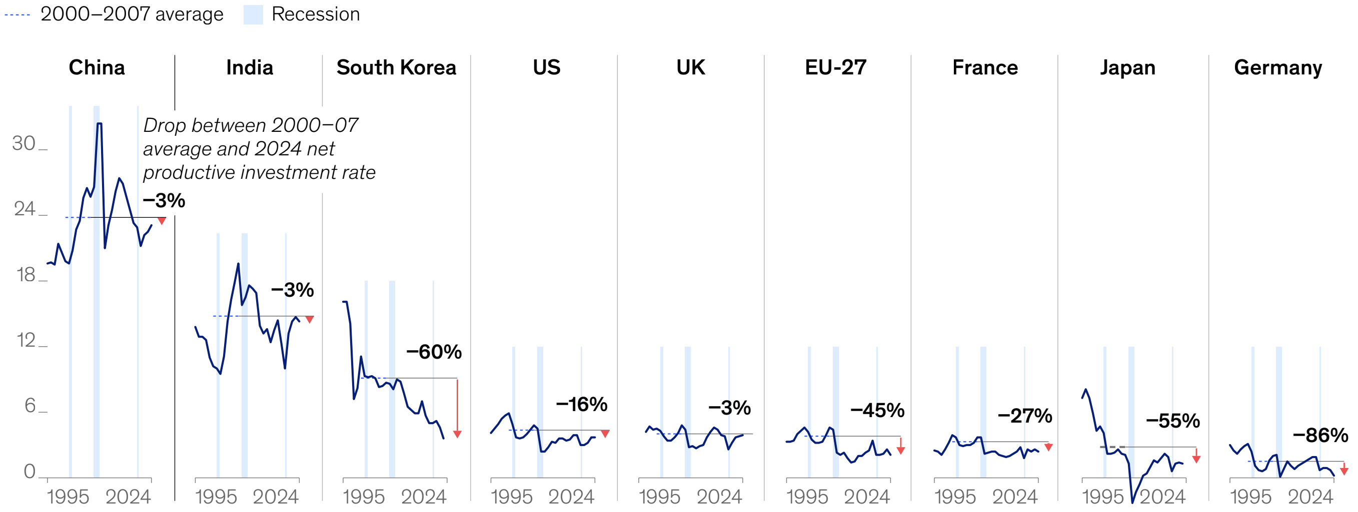
United States: Investment shifted into higher-return asset classes, notably software and the AI value chain

The 2008 financial crisis had a different impact on the United States and other advanced economies than on China and other emerging economies. US net investment, which peaked at about 6 percent in 2000, took a big hit in 2008 and has hovered consistently between 3 and 4 percent since 2010 (Exhibit 6). This decrease is less pronounced than in other advanced economies but has nevertheless dampened growth.

Exhibit 6

The pattern of net investment has shifted over time across economies.

Net productive investment, 1995–2024, % of GDP



Source: National statistical agencies; S&P Global Market Intelligence; McKinsey Global Institute analysis.

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However, the United States today invests much more in intangible assets, such as software and R&D, than it did before the crisis (Exhibit 7). These assets are thought to produce higher shareholder returns and socioeconomic benefits.[20] Indeed, the US economy has benefited from much stronger productivity growth than most other advanced economies over the past two decades.[21]

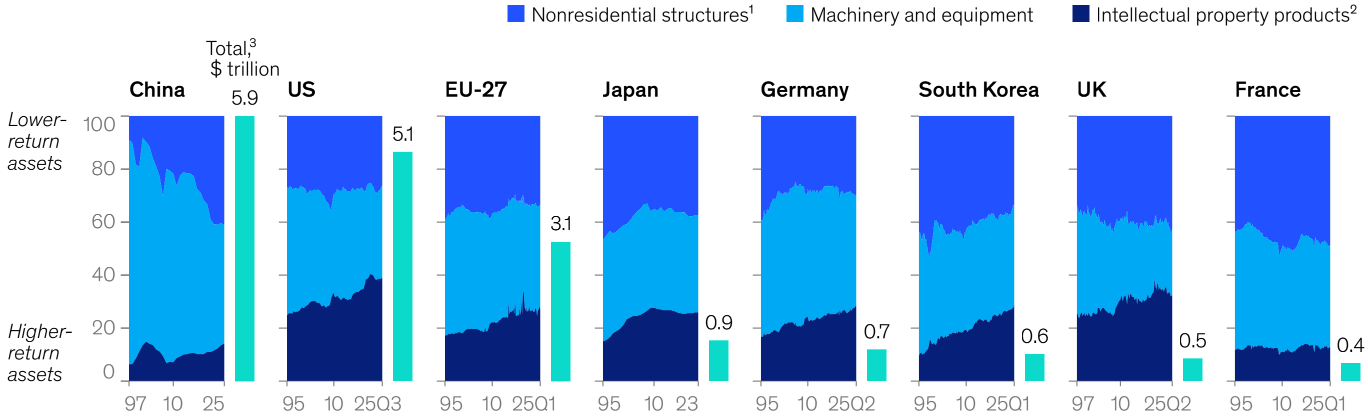
Most recently, the race to build AI data centers has attracted a tsunami of investment globally, with the United States at the epicenter. Seven AI-related companies increased their combined capital expenditures and R&D investments 50-fold over two decades, from $15 billion in 2005 to close to $750 billion in 2025. By the end of 2026, total investment among these hyperscalers could approach an eye-catching $1 trillion.[22] The AI boom is sometimes likened to the flood of railroad investments in the 19th century, although at a little less than 2 percent of GDP in 2025, technology-related investment falls well below the peak years of that boom, when investment in railroads exceeded 10 percent of GDP.[23]

A school of thought in Silicon Valley and elsewhere contends that AI and robotics will trigger a broad investment revival by reducing costs across the economy, making traditional manufacturing and services competitive again.[24] This view implies that the gap in broad-based capital investment between advanced economies and China is largely irrelevant because AI computing infrastructure is a uniquely transformative input.

Exhibit 7

Investment has been shifting to intangibles, especially in the United States.

Gross productive investment by asset type, % of total



[1] Nonresidential structures include commercial and industrial buildings and infrastructure.
[2] Intellectual property products (IPP) include capitalized R&D expenses and software expenditure.
[3] 2024 data except for Japan (2023).
Source: National statistical agencies; McKinsey Global Institute analysis

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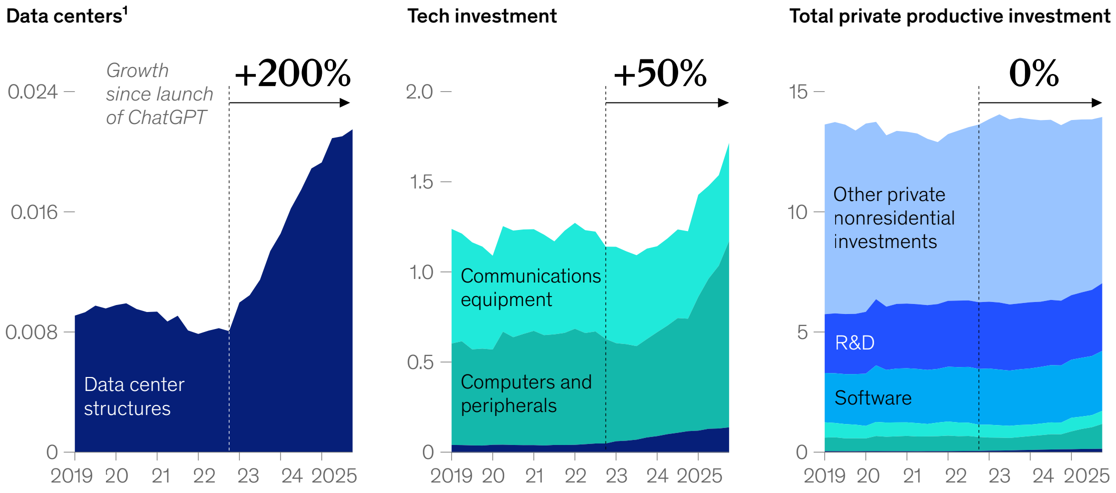
So far, however, the boom in AI investment has not led to a broader investment revival (see sidebar “United States: Investments beyond tech show a mixed picture”). In the United States, investments in data center structures have increased 200 percent in the three years following the launch of ChatGPT at the end of 2022, and broader technology investment increased by 50 percent over the same period. Yet total productive investment as a percentage of GDP in the United States remained flat, because many investments unrelated to technology, software, and R&D declined relative to GDP (Exhibit 8). Recent MGI research on US manufacturing found that addressing the risks arising from the most critical US import dependencies could require on the order of $2 trillion in total additional manufacturing investment—a figure equivalent to about 6 percent of US GDP, putting the current flat trajectory in stark relief.[25]

These patterns could, of course, change in the future, with additional investments in areas such as energy infrastructure to support AI and semiconductor fabrication plants, or “fabs.” If AI investment leads to the hoped-for productivity gains and acceleration of innovation cycles, it could lead to a broader investment renaissance in the United States and globally.

Exhibit 8

AI investment is booming in the United States, but overall investment there is flat relative to GDP.

United States quarterly private productive investment, % of GDP


Data centers[1]

Tech investment

Total private productive investment

[1] Data center investment shown for 2025 reflects structures only and represents a portion of the overall $436 billion invested by hyperscalers.

Source: US Bureau of Economic Affairs; McKinsey Global Institute analysis

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Sidebar

United States: Investments beyond tech show a mixed picture

Beyond tech investments, investment in the United States suggests selective growth and broad decline in four distinct areas (exhibit). In infrastructure, investment has decidedly focused on "green" electricity structures, increasing 12 percent from 2024 to 2025. But investment in oil and gas structures, still the largest infrastructure investment category, contracted by 12 percent over that period.[1]

Manufacturing investment showed signs of plateauing after initial reshoring-driven momentum linked to the 2022 Inflation Reduction Act and CHIPS Act (exhibit).[2] Investment in factory structures declined 6 percent from 2024 to 2025 after peaking the prior year, while general industrial equipment held roughly flat at 1 percent. Specialized industrial equipment grew strongly at 9 percent, hinting at investments in the semiconductor value chain.

Building investment declined broadly. Investment in office buildings dropped 13 percent, reflecting the entrenchment of hybrid work, while investment in warehouses dropped 12 percent as the pandemic e-commerce surge plateaued.[3] Other commercial real estate investment declined by 12 percent.

In transportation equipment, aviation investment recovered after the pandemic and associated manufacturing difficulties, recording a 47 percent increase. Meanwhile, investment in the automotive industry declined 8 percent as the industry recovered from a chip shortage. Investment in other areas was broadly stable. In aggregate, a historic technology build-out has so far shifted the composition of the US economy rather than adding to aggregate investment.

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[1] Federal Reserve Economic Data (FRED), "Value of construction put in place in manufacturing," Federal Reserve Bank of St. Louis, accessed May 18, 2026.

[2] Omar Barbiero, "Manufacturing gains from green energy and semiconductor spending since the CHIPS and Inflation Reduction acts," Federal Reserve Bank of Boston Current Policy Perspectives, November 19, 2024.

[3] *Empty spaces and hybrid places: The pandemic's lasting impact on real estate*, McKinsey Global Institute, July 13, 2023.

Sidebar (continued)

United States: Investments beyond tech show a mixed picture

Exhibit

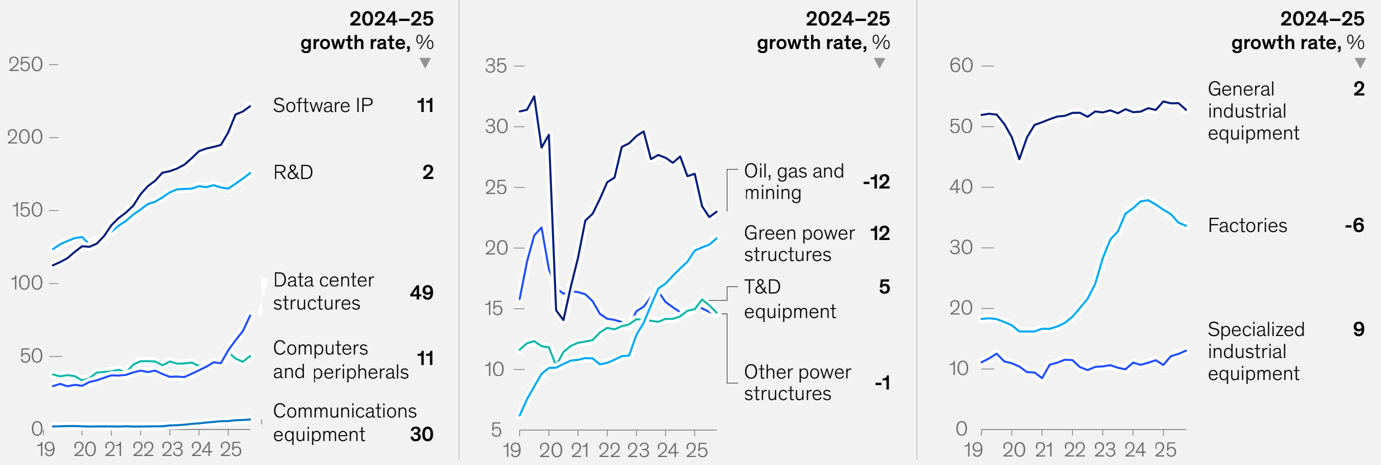
In the United States, investment in tech and green energy are up, and nonresidential building has declined.

Private productive investment by categories, quarterly 2019–25, constant 2024 $ billion

Technology: continued acceleration

Energy infrastructure: growth in green

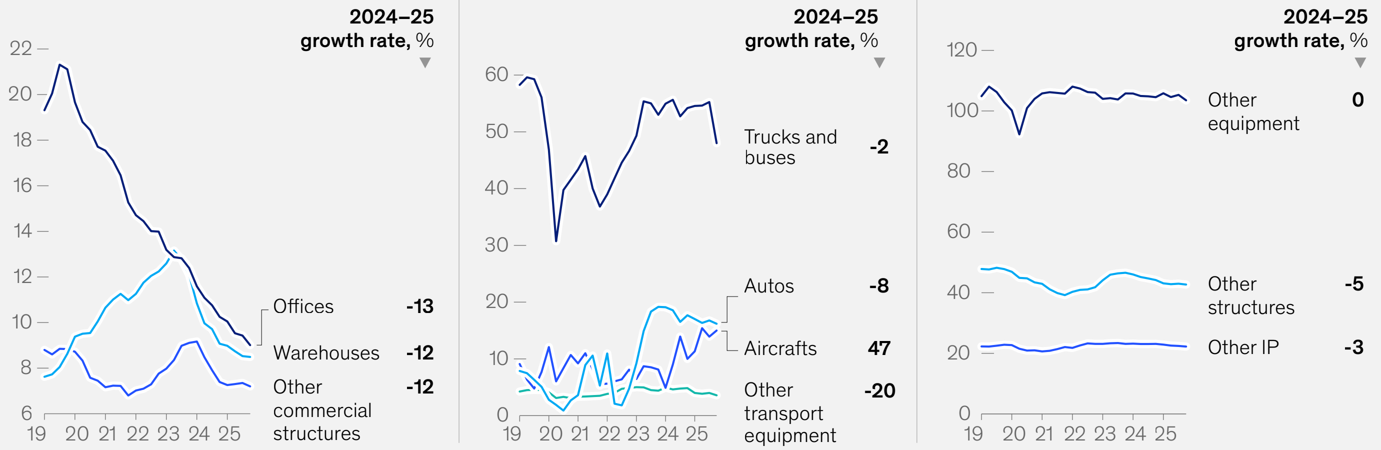
Manufacturing: signs of plateauing



Buildings: overall decline

Transport equipment: aviation and auto recovery

Other[1]**:** stable



[1] Other equipment includes medical instruments, furniture and fixtures, agricultural machinery, household appliances, and other miscellaneous equipment. Other structures include healthcare, communication, transportation, and other miscellaneous structures. Other IP includes entertainment, literary, and artistic investments.
Source: US Bureau of Economic Analysis; McKinsey Global Institute analysis

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Other advanced economies: Investment in Japan and many European countries is consistent with GDP growth below 1 percent

Investment in other advanced economies was even more affected by the 2008 financial crisis and the policy responses to it than US investment was. Across five advanced economy regions—the EU-27 and United Kingdom, Japan and South Korea, and the United States—net investment is now almost $900 billion less annually than it would have been had those regions invested in line with their previous averages (Exhibit 9).

The 2008 global financial crisis and the 2009-10 eurozone debt crisis affected many countries in the EU-27 strongly. The region's net productive investment rate declined from just below 4 percent of GDP in the years running up to 2008, to just over 2 percent of GDP in 2024. This 40 percent drop was more material than in the United States and further widened the region's significant investment gap.

This aggregate figure masks large differences between European countries. In Europe's largest economy, Germany, where policy responses to recent crises focused on debt consolidation (*Schuldenbremse*), net productive investment dropped from about 2 percent of GDP before the financial crisis to just 0.2 percent in 2024. Growth in the capital stock available per worker has virtually ground to a halt, a brake on economic growth. The countries most exposed to the eurozone debt crisis in 2009-10 have much higher net investment rates than Germany today: at more than 2 percent in France, Italy and Spain, and more than 4 percent in Greece and Portugal.[26] Countries in Central, Eastern and Northern Europe have the highest investment pulse on the continent: Denmark and Sweden have net productive investment rates of about 5 to 6 percent of GDP, and the figures for Poland and Romania range from 6 to more than 8 percent.

Perhaps surprisingly, net investment in the United Kingdom, noted for its low investment pulse, has declined less than in other European countries. This is in part because its productive capital stock with a value equivalent to 0.8 times GDP is small compared to other advanced economies, where the capital stock is worth 1.0 to 1.1 times GDP—there is less capital consumption to subtract from gross investments.[27]

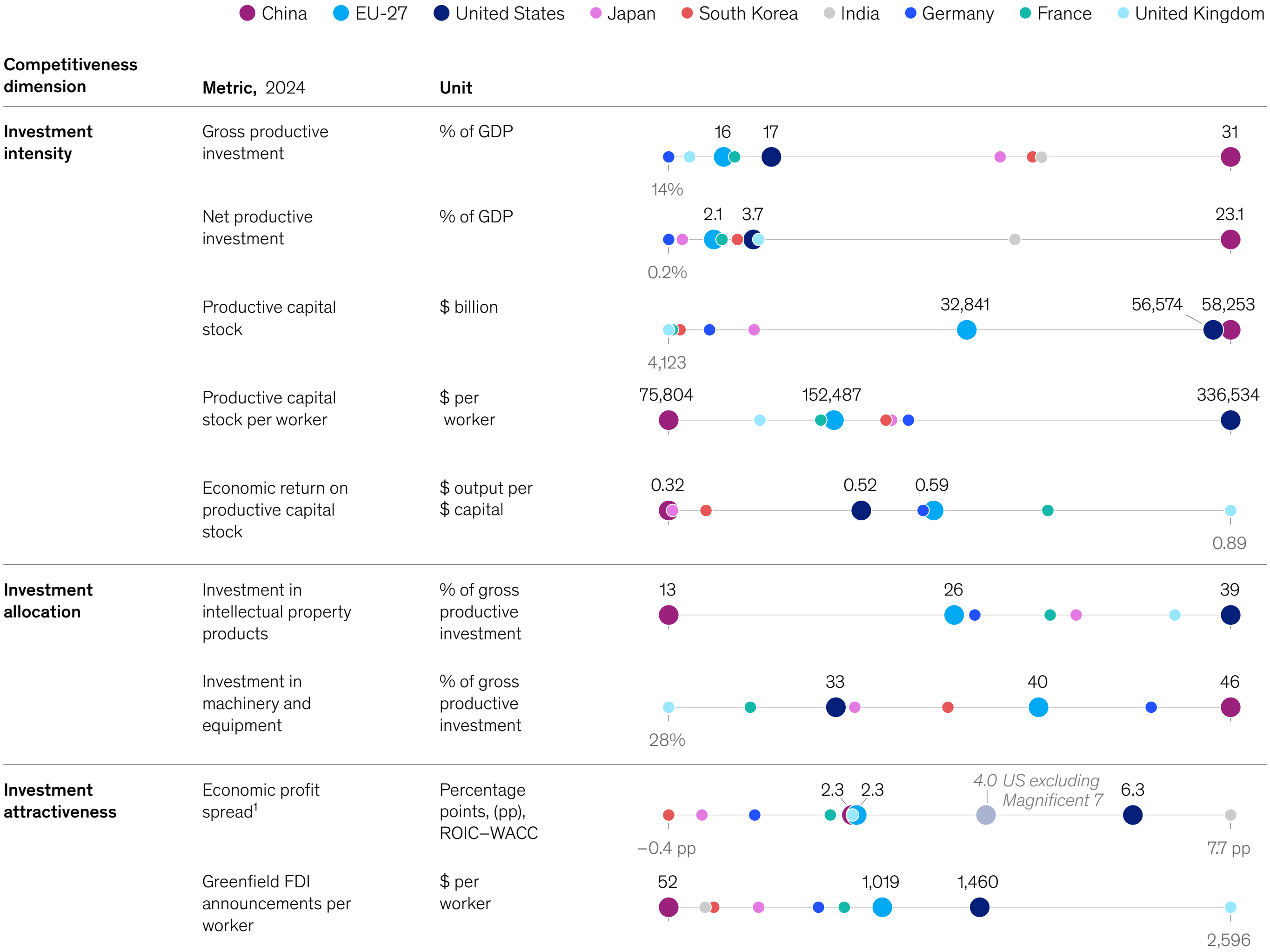
Previous MGI research identified Europe's low investment rate as the main reason behind its lagging growth, a diagnosis shared by the European Commission and the influential report led by Mario Draghi, former president of the European Central Bank and former prime minister of Italy. To close the investment gap identified in this report and MGI's research on European investments, Europe would need to increase its investments, largely private, by €750 billion to €800 billion per year, or approximately 4.5 percentage points of GDP—a bold ambition that it is currently far from achieving.[28]

Advanced Asian economies also saw a drop, albeit from higher levels. In Japan, the net investment rate declined by more than 70 percent to about 1.5 percent of GDP in 2024; in South Korea, it dropped by about half, to just under 4 percent of GDP.

Economies tend to maintain relatively stable ratios of productive capital stock to GDP over long periods, so an economy's growth rate largely tracks net investment or growth in capital stock.[29] This relationship runs both ways: Weaker growth reduces incentives to invest, while lower investment slows the rate of capital deepening and productivity growth, leading to lower economic growth going forward. By that rough yardstick, the United States is investing in line with GDP growth of about 2 percent, while the EU-27 is building productive capacity consistent with just 1 percent GDP growth—around 0.5 percent in Germany, for example—well below the region's stated objectives.[30] Japan's current rate of investment is consistent with no GDP growth at all.[31]

Exhibit 9

Investment competitiveness scoreboard.



[1] Average 2020–24.

Source: Eurostat; national statistical agencies; S&P Global Market Intelligence; OECD; UNCTAD; ILO; World Bank; McKinsey Global Institute analysis

McKinsey & Company

The investment divergence foreshadows a remapping of the global economy

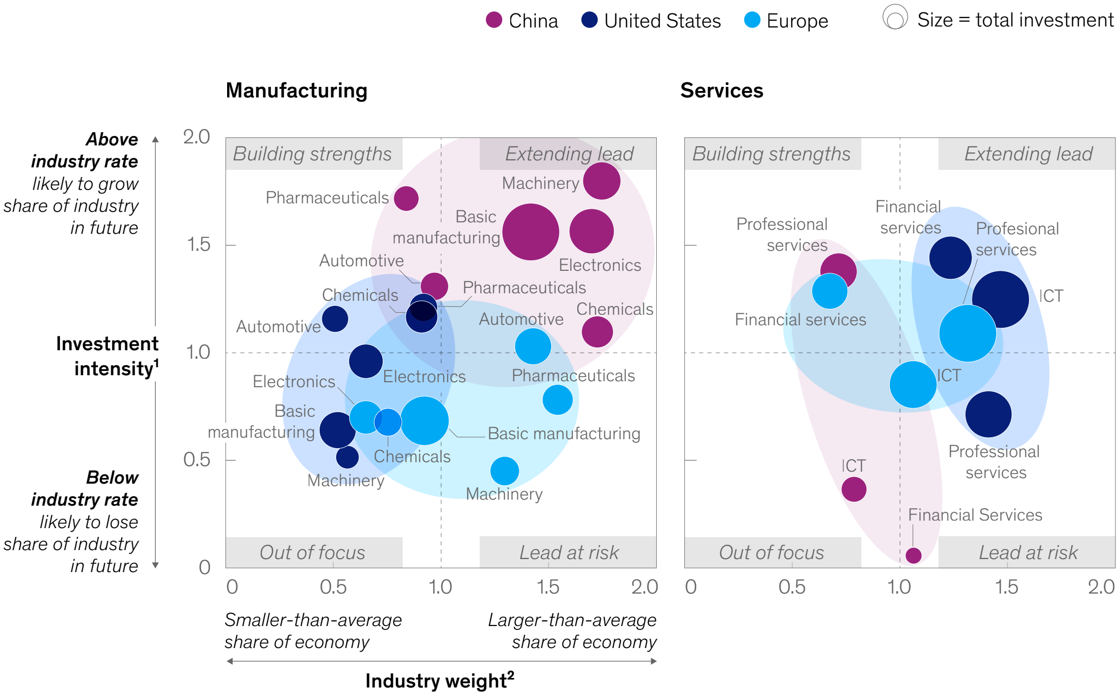
Investment is a leading indicator for changes in production footprints, and investment profiles offer another way to assess comparative advantage and growth trajectories beyond traditional trade metrics. Comparing investment with an industry's current value added across countries shows which economies are building future capacity fastest relative to the size of their existing base. Because investment precedes production, this is also a forward-looking indicator. Countries that consistently invest more than their current production share tend to gain output share over time. This is illustrated by China's above-average investment intensity in manufacturing sectors over past two decades, which was followed by sizable gains in its share of global output, and by the equivalent for US investment in the information and communications technology (ICT) industry.

Comparing relative investment intensities against current levels of specialization by country and industry provides a good snapshot of current and future trends in comparative advantage and production footprints (Exhibit 10).[32]

Exhibit 10

Current patterns of investment in China and the United States will extend their respective leads in manufacturing and services.

Investment intensity and level of specialization by sector, indexed to global average (1.0)



[1] Investment intensity is calculated as a region's share of global gross fixed capital formation in an industry divided by its share of global gross value added in that industry. A value above 1.0 indicates investment above the global average relative to output.

[2] Weight here means level of specialization, which is calculated by dividing an industry's gross value added by the gross value added of the country in which that industry is located, compared to the global average.

Source: S&P Global Market Intelligence; OECD; Oxford Economics; McKinsey Global Institute analysis

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A country's investment intensity is made up of two parts, its share in an industry's global value added and its share in global investment. When compared, they offer a clear picture of shifting production footprints (Exhibit 11). China is investing to extend its lead in sectors in which it is currently specialized, namely almost all manufacturing subsectors (increasingly including high-tech industries), an explicit goal of its Made in China 2025 strategy.[33] Additionally, China is investing to grow in other industries such as utilities, pharmaceuticals, and professional services. By contrast, it is underinvesting in financial services and—surprisingly given its emergence as the main AI rival to the United States—in ICT. This underinvestment in ICT speaks to either phenomenal capital efficiency in its technology development approach or mismatches in accounting treatments and modeled approximations provided by economic research institutions in the absence of reliable national sectoral statistics.[34]

Exhibit 11

China is the top investor in five of six manufacturing industries, signaling further growth in those industries there.

% of 2024 gross value added (GVA) and gross fixed capital formation (GFCF)

[1] Investment intensity is calculated as a region's share of global gross fixed capital formation in an industry divided by its share of global gross value added in that industry. A value above 1.0 indicates investment above the global average relative to output.

Source: OECD when available and S&P Global Market Intelligence when not available; Oxford Economics for China; McKinsey Global Institute analysis

McKinsey & Company

The United States is extending its lead in ICT and financial services as well as investing somewhat to expand its footprint in automotive, chemicals, and pharmaceuticals. Europe, with an investment intensity that lags behind its current share of global production, risks losing its lead in many historic strongholds, including automotive, pharmaceuticals, and machinery. Measured by investment intensity, the region is investing for a growing footprint in agriculture and professional and financial services.

The shifting investment patterns around the world are changing the global cartography of growth and competitiveness. Layer on global geopolitical shifts, and the need to establish a new balance comes into focus. To understand why investments are being made so readily in some countries and industries and less readily in others, we take a deep dive in the next chapter into the line-by-line economics of ten business projects spanning the industries discussed in this chapter, including utilities (nuclear and solar power generation), basic manufacturing (EAF steel), chemicals (polyethylene), automotive (EV platform development), electronics (batteries and advanced semiconductors), pharmaceuticals and life sciences (biotech R&D and pharma manufacturing), and ICT (colocation data centers).

CHAPTER TWO

The bottom-up case for investment

What drives the divergence in investment trajectories, and what could be done to establish a new balance? Many macroeconomic factors underpin differing investment patterns across regions, including structural trends like the rapid growth of China's urban middle class, aging populations in East Asia and Europe, varied monetary and fiscal responses to the 2008 financial crisis and the 2009-10 eurozone debt crisis, and the impact of the tech industry in the United States.[35]

This report, however, focuses on micro-level decisions that shape business investments across geographies, particularly levelized costs. A large share of investment, especially outside China, is made by global companies that commit capital at scale only in places where expected returns are attractive relative to risk. In global markets, this often requires competitive costs.[36] In this chapter, we examine ten examples to understand what makes or breaks each investment case and what could be done to improve it.

Business cases must add up to unlock private investment

A range of factors influence investment decisions. Many strategic considerations come into play, including which markets and technologies to expand into or enter, what types and levels of risk are acceptable, where projects proceed quickly and efficiently, and what is needed to build resilience. Industrial policy also impacts investment, encouraging investments in some technologies and steps of the value chain that support nascent industries and to bolster strategic autonomy or avoiding or creating chokeholds, among other considerations. At bottom, a positive business case is a prerequisite for large-scale investments. Typically, a company will require that expected net present value, or the risk-adjusted value of a project's expected cash flow, is positive and better than other options to proceed with any investment.

The decisions vary by type of industry. "Anchored" industries providing goods or services that aren't traded on global markets need to decide whether local market structures and prices are attractive relative to the cost of, say, building energy substations or laying fiber optic cables. "Footloose" industries that trade their products far and wide will choose where it is most cost-effective and profitable to make an investment relative to other geographies. To companies in industries that feature rapid innovation and an escalatory investment race to the top—industries we call new "arenas" of competition—being able to move fast and to find partners and investors in local ecosystems matters most.

This research examines line items in business cases in ten industries in order to understand what shapes investment decisions and competitiveness. While these cases don't represent the entire economy by any means, we selected them because they illustrate relevant and strategically important themes as well as a variety of factor intensities of production, such as capital, energy, and labor.

Analysis of ten industries that represent a cross-section of the global economy forms the foundation of this research

The ten cases span the three archetypes—anchored, footloose, and arena industries—with an emphasis on footloose industries, which are most exposed to global competition (Exhibit 12). Two cases, nuclear reactors and solar photovoltaic production with battery energy storage systems (PV and BESS) look at **anchored industries**. Both are capital expenditure intensive, and construction and equipment costs are key determinants of their business cases. Because anchored industries are not traded much, the main investment decision for them is about competitiveness in a local market rather than across global production locations. For instance, is there enough domestic demand, and are the costs of the electricity generated acceptable to the government or private offtakers?[37]

Five other cases—steelmaking in direct reduced iron–electric arc furnace or DRI–EAF plants, polyethylene crackers that manufacture commonly used petrochemicals, battery gigafactories, advanced semiconductor fabs, and production sites for pharmaceuticals—focus on **footloose industries**. These industries' products are traded around the planet, and so their products are priced in relation to world markets. A business case for a footloose industry is most likely to be positive if its costs after transportation and tariffs are at least as competitive as in other locations where it could produce the same good or service. For instance, could a steel mill in one country compete against a steel mill in another country that has lower energy costs?

Colocation data centers, automotive R&D that underpins a new electric vehicle (EV) platform, and biotech R&D that leads to new molecular therapies are three examples of projects in **arena industries**. Investment decisions in these industries are heavily influenced by an ongoing need to improve capabilities and an ability to move fast, from permitting to hiring to fundraising, and so on. They often concentrate in geographic clusters where talent, investors, infrastructure, and partners are in close proximity, such as San Francisco–San Jose ("Silicon Valley") or Beijing, Shanghai, and Shenzhen in the case of AI.[38]

Exhibit 12

Ten investment cases are at the foundation of this research.

	Anchored industries	Footloose industries		Arenas industries	
Case	**Nuclear** (Gen III+ fission)	**EAF steel** (DRI-EAF HRC)	**Pharmaceuticals** (mAb manufacturing)	**Colocation data centers** (AI, excluding chips)	**Biopharma R&D** (fast-follower mAb)
Industry	Utilities	Basic manufacturing	Pharmaceuticals	ICT	Pharmaceuticals
Description	1,000 MW Generation III+ reactor	2.5t hot-rolled coil flat steel from direct reduced iron-electric arc furnace plant	1,200 kg monoclonal antibody drug substance production plant	100 MW colocation data center, excluding chips	New fast-follower monoclonal antibody drug discovery and development
Primary driver of cost gap	Capex (construction)	Energy	Labor	Energy	Speed
Case	**Solar** (PV + BESS)	**Polyethylene** (HDPE)	**Batteries** (LFP assembly)	**Semiconductors** (advanced-node fab)	**Automotive R&D** (EV platform)
Industry	Utilities	Basic manufacturing	Electronics	Electronics	Automotive
Description	250 MW solar photovoltaic power and battery energy storage system	1 million metric tons per year of ethylene capacity feeding a 400,000 metric ton per year high-density polyethylene unit	50 GWh lithium iron phosphate gigafactory	400,000 wafers per year 28 nanometer logic chip fab	New C/D segment passenger car EV platform
Primary driver of cost gap	Capex (equipment)	Materials	Materials	Labor	Labor

Source: McKinsey Global Institute analysis

McKinsey & Company

We compare investment cases using a levelized-cost framework, as well as other factors that influence investment decisions

To compare investment competitiveness in different industries and geographies, we use a levelized cost framework. Levelized cost is the sum of all operating expenses, repayment of debt and accrued interest on initial project expenses, and an acceptable return to investors over the life cycle of a project, based on typical weighted average cost of capital (WACC). It is equal to the unit price that would make a project's net present value equal to zero over its entire life cycle, rendering that project viable, and it corresponds to the established macroeconomic concept of long-run marginal costs.

This method allows us to compare the cost competitiveness of different industries in different geographies. For each investment case, we analyze a standard set of cost drivers including capital expenditures for construction and equipment, labor costs, inputs such as materials and energy, and performance drivers such as time to market, scaling effects, and financing conditions. Comparing levelized costs across geographies and investment cases can explain which cost drivers contribute to differences in competitiveness and to what degree (see sidebar "About the levelized cost methodology"). The set of economies we analyze always includes Mainland China, the United States, and the leading European country by investment in an industry, plus any other countries worldwide among the top three for global investment in that industry.

Sidebar

About the levelized cost methodology

Our levelized cost methodology converts a project's full life-cycle economics into a single unit cost. It can be interpreted as the unit price that would make a project's net present value equal to zero over its entire life cycle, making that project viable, and is in line with the macroeconomic concept of long-run marginal costs.[1] The concept is commonly applied in the energy sector, where it is known as levelized cost of energy. We do not consider taxes, subsidies, and externalities, which vary and are hard to pin down.

We model capital expenditures and operating expenditures as time-phased cash flows, discount them using the local weighted average cost of capital and divide by discounted lifetime output to calculate the levelized cost. The line items captured in the analysis include construction costs, equipment costs, labor costs—determined by wages as well as hourly productivity and hours worked—and operating costs such as materials, energy, and maintenance. The modeling includes additional case-specific inputs such as time to market and scale effects where relevant.

To understand how each driver influences levelized cost, we compare each region to the base case by replacing one factor at a time. For example, in the semiconductor investment case, we ask how the cost of producing a wafer would change if a German semiconductor employee paid Taiwanese wages. An interaction effect captures the fact that some drivers influence each other and do not add up perfectly on their own (for example, longer construction duration matters more in a region with a higher weighted average cost of capital).

The case of an advanced semiconductor fab illustrates how the levelized cost method works in practice (exhibit). We analyze a representative facility producing 400,000 units of 300-millimeter wafers a year and use it as a benchmark for the levelized cost of one wafer in dollars in the economy that has attracted the most investment, in this case Taiwan. We compare its levelized cost with the levelized cost of producing the same chip in comparable factories in Mainland China, the United States, and Germany, the European economy currently seeing the most investment in semiconductor fabs.

In industries where market prices are comparable across economies, levelized cost is a proxy for returns on investment. In the case of semiconductors, there are reported price differences of up to 30 percent between chips made and sold in Mainland China and Taiwan, meaning that investments in higher-cost locations can often be profitable.

All figures in the investment case are expressed in 2024 dollars, converted from local currencies using 2024 market exchange rates.

Our business cases are informed by McKinsey's work on the ten industries, which provides our understanding of how much capital, labor, energy, materials, and other inputs are typically needed to produce a product—here, a semiconductor wafer—and how long the process typically takes. We price these inputs at the typical costs in a geography, also drawing on the proprietary databases maintained by MGI's Economics Research team, and typical weighted average cost of capital, drawing on McKinsey's Value Intelligence platform, a curated global database of corporate financials.

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[1] Stefan Reichelstein and Anna Rohlfing-Bastian, *Levelized product cost: Concept and decision relevance*, Stanford Law School, August 2013; Paul Samuelson and William Nordhaus, *Economics*, 10th edition, McGraw-Hill, 1976.

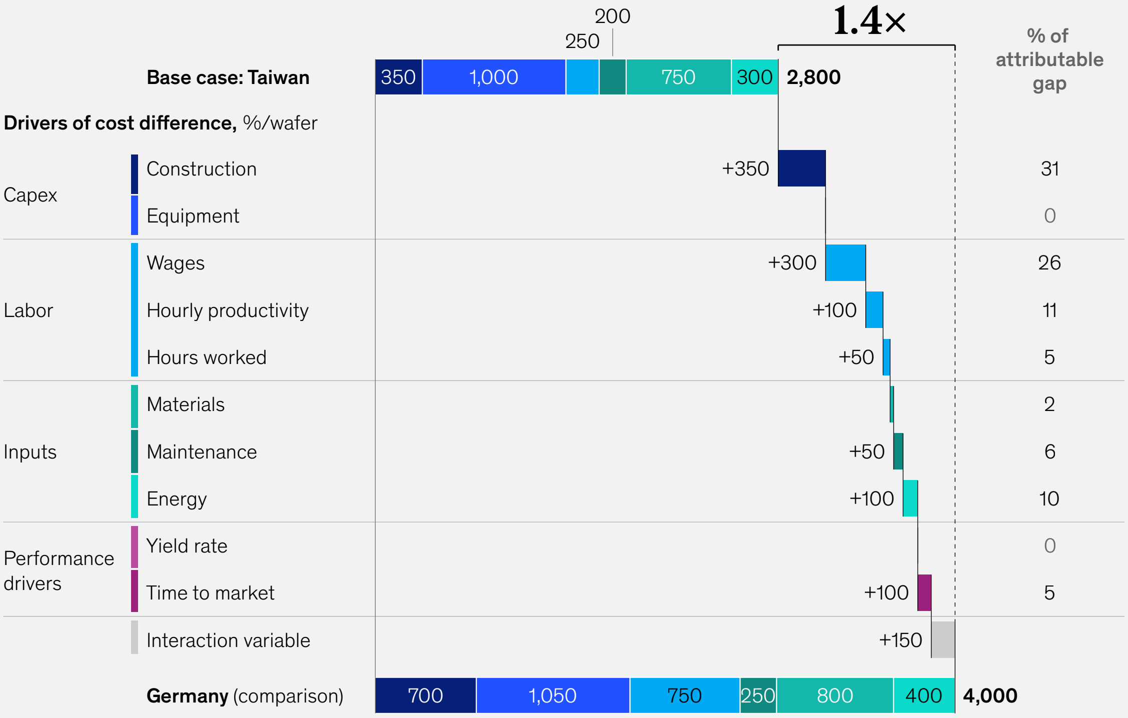
Sidebar (continued)

About the levelized cost methodology

Exhibit

Levelized cost example - Advanced semiconductors.

Levelized cost of advanced semiconductors,[1] $/wafer, before taxes and direct subsidies



[1] We use a 28-nanometer node size in a 400,000 wafer starts per year fabrication plant for comparison.
Source: McKinsey Global Institute analysis

McKinsey & Company

Final investment decisions will consider factors beyond levelized cost. Chief among them are revenues, but also factors such as regulatory stability, domestic market dynamics, local industrial ecosystems, geopolitical shifts and trade impediments, and industrial policy. We take all of these as given. This is an important constraint, especially for anchored industries in which strategic considerations such as supply chain sovereignty, employment, and energy security often weigh as heavily as economics, and for arena industries, where ecosystem and dynamism effects dominate. A government may opt to support a domestic steel plant or refinery to maintain industrial capacity and reduce import dependence, regardless of whether it is the lowest-cost option globally; and technology companies continue to flock to Silicon Valley, even though wages and energy costs are higher than elsewhere. Nevertheless, levelized cost provides a solid quantitative assessment of the financial differences that need to be bridged by other factors, such as revenues, quality of talent, or abundance of financing). Levelized cost ends up providing a fairly solid explanation for where investment actually goes in many industries, which we turn to at this chapter's end.

European and US levelized costs are 50 to 300 percent higher in many industries than in best-in-class countries

We analyzed cost differences by region by examining the top five investment locations for each industry (Exhibit 13). In-depth analysis of the ten industries can be found in the appendix.

The variation in levelized costs is biggest in nuclear power and, perhaps somewhat surprisingly, automotive R&D. When it comes to nuclear power, France's costs per megawatt for a newly built, third-generation fission reactor are roughly three times the costs in Mainland China and South Korea, which are virtually equal as the lowest-cost locations globally. Although electricity generated by a nuclear power plant isn't traded over long distances, such differences still determine where a build-out is economical and thus whether it proceeds. It's no surprise that over the past decade, three in four new nuclear plants built globally were in Asia, more than half in Mainland China.[39]

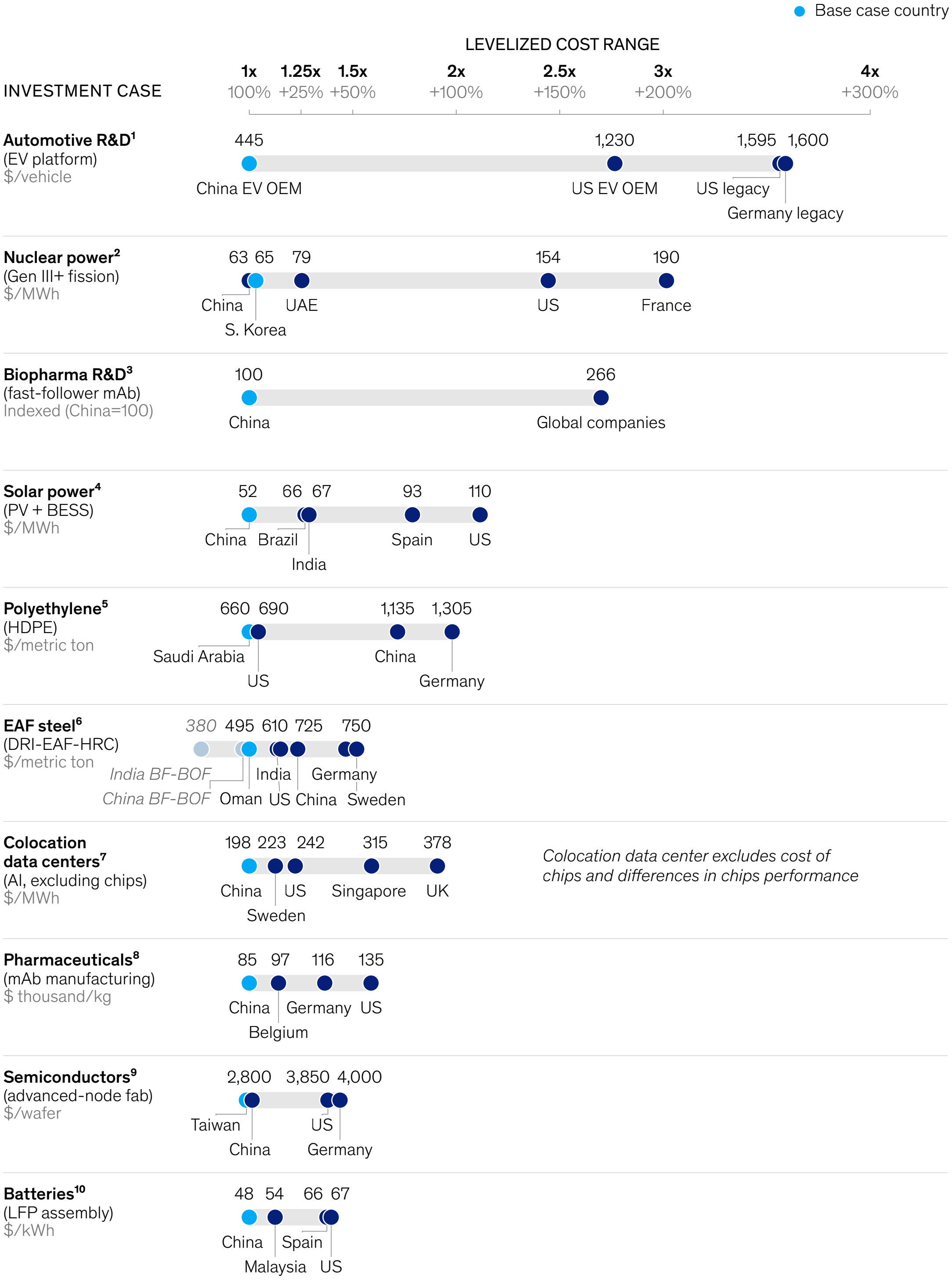
Similarly, the cost of developing a new EV platform for a German or US incumbent car company is about three to four times as much as for a Chinese EV manufacturer. From 2021 to 2024, Mainland China's share of global EV sales grew from 50 to 65 percent, and as of the end of 2025, one in two new car models globally was launched by a Chinese manufacturer.[40]

Cost differences are much narrower in industries such as advanced semiconductor and battery manufacturing, in large part because costs in these industries are driven by globally tradable input materials. Nonetheless, producing advanced semiconductor chips in Germany or the United States costs about 40 to 50 percent more than in Taiwan or Mainland China, and a similar cost gap holds for producing batteries in Europe and the United States compared to Mainland China. Such gaps can be prohibitive, given that both industries produce easily tradable goods and manufacturing capacity is abundant, especially in the case of batteries. This explains why more than 65 percent of advanced semiconductor foundry capacity and approximately 85 percent of battery cell production capacity are in Taiwan and Mainland China, respectively.[41]

Exhibit 13

Competitiveness varies widely across industries and among regions.

Levelized cost comparison across regions and investment cases, before taxes and direct subsidies



Colocation data center excludes cost of chips and differences in chips performance

[1] New C/D segment passenger car EV platform development. [2] 1,000 MW Generation III+ reactor. [3] New fast-follower monoclonal antibody drug discovery and development. [4] 250 MW solar photovoltaic power and battery energy storage system. [5] 1 million metric tons per year of ethylene capacity feeding a 400,000 metric ton per year high-density polyethylene unit. [6] 2.5t hot-rolled coi flat steel from direct reduced iron-electric arc furnace plant. [7] 100 MW colocation data center, excluding chips. [8] 1,200 kg monoclonal antibody drug substance production plant. [9] 400,000 wafers per year 28 nanometer logic chip fab. [10] 50 GWh lithium iron phosphate gigafactory.

Source: McKinsey Global Institute analysis

Capital expenditures, labor, materials, and energy all contribute to the cost gap

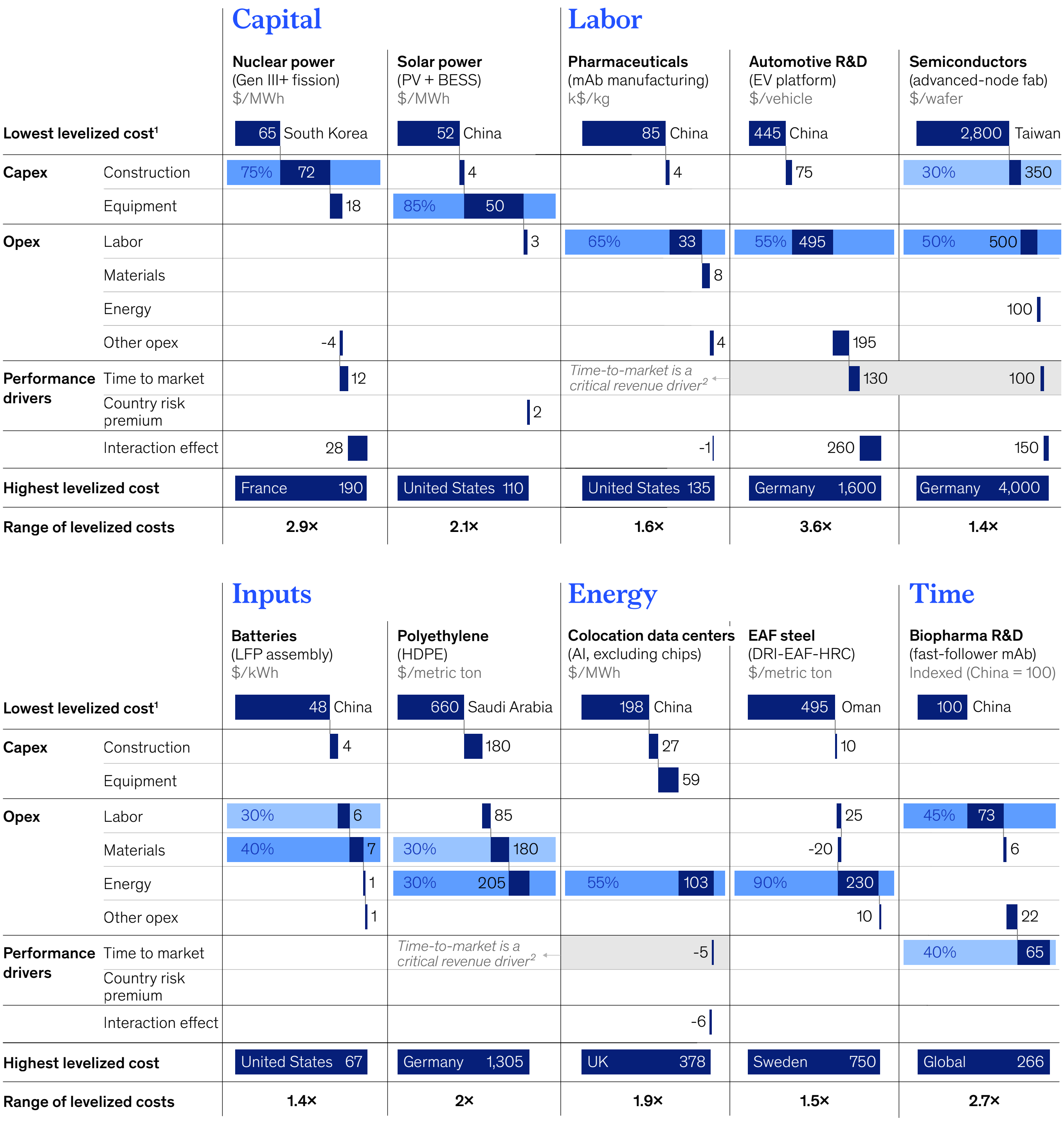
Examining the line items in the levelized cost calculation between countries clarifies the sources of competitive advantage or disadvantage and points to levers that could be used to restore a balance. Exhibit 14 details the cost gap between the base-case location, a country with high investment and low levelized cost, and the highest-cost location in our sample, always including China, a European country, the United States, and any other countries home to major investment in an industry globally. The rest of this chapter discusses each driver of variation in more detail.

Exhibit 14

The gap between the lowest- and highest-cost locations ranges from 1.4× to 3.6× in our sample.

Drivers of variation in levelized cost, before taxes and direct subsidies

🟦 Primary driver of variation   ▨ Secondary driver of variation   **xx%** Percentage of gap to best



		Capital		Labor		
		Nuclear power (Gen III+ fission) $/MWh	**Solar power** (PV + BESS) $/MWh	**Pharmaceuticals** (mAb manufacturing) k$/kg	**Automotive R&D** (EV platform) $/vehicle	**Semiconductors** (advanced-node fab) $/wafer
Lowest levelized cost[1]		65 South Korea	52 China	85 China	445 China	2,800 Taiwan
Capex	Construction	75% 72	4	4	75	30% 350
	Equipment	18	85% 50			
Opex	Labor		3	65% 33	55% 495	50% 500
	Materials			8		
	Energy					100
	Other opex	-4		4	195	
Performance drivers	Time to market	12		*Time-to-market is a critical revenue driver*[2]	130	100
	Country risk premium		2			
	Interaction effect	28		-1	260	150
Highest levelized cost		France 190	United States 110	United States 135	Germany 1,600	Germany 4,000
Range of levelized costs		**2.9×**	**2.1×**	**1.6×**	**3.6×**	**1.4×**

		Inputs		Energy		Time
		Batteries (LFP assembly) $/kWh	**Polyethylene** (HDPE) $/metric ton	**Colocation data centers** (AI, excluding chips) $/MWh	**EAF steel** (DRI-EAF-HRC) $/metric ton	**Biopharma R&D** (fast-follower mAb) Indexed (China = 100)
Lowest levelized cost[1]		48 China	660 Saudi Arabia	198 China	495 Oman	100 China
Capex	Construction	4	180	27	10	
	Equipment			59		
Opex	Labor	30% 6	85		25	45% 73
	Materials	40% 7	30% 180		-20	6
	Energy	1	30% 205	55% 103	90% 230	
	Other opex	1			10	22
Performance drivers	Time to market		*Time-to-market is a critical revenue driver*[2]	-5		40% 65
	Country risk premium					
	Interaction effect			-6		
Highest levelized cost		United States 67	Germany 1,305	UK 378	Sweden 750	Global 266
Range of levelized costs		**1.4×**	**2×**	**1.9×**	**1.5×**	**2.7×**

[1] Values might not add up due to rounding.
[2] Time-to-market is a critical revenue driver, even though not of levelized costs.
Source: McKinsey Global Institute analysis

Construction: Differences in costs and timelines explain up to one-third of the cost gap in manufacturing industries and 60 to 80 percent in nuclear energy

Nuclear power is one of the most capital expenditure-heavy and complex industries in the world, and levelized costs of nuclear power generation differ by three times between France and South Korea. Differences in construction costs explain almost 60 percent of that gap.

Construction costs are determined by input costs as well as by time and efficiency. Lower costs of inputs such as cement, steel, and construction labor in some regions change the calculus. Costs of, steel, concrete, and construction labor cost are approximately twice as much high in Europe and the United States as in South Korea, and the gap with China is even more pronounced.

Higher levels of standardization and delivery discipline and lower build times also have an impact on construction costs, further widen the gap. Benchmark programs in China average roughly 70 months, or a little less than six years, from the time concrete is first poured to completion of a unit; that figure is close to 100 months, or a little more than eight years, in South Korea and the United Arab Emirates. By contrast, recent projects in Europe and the United States have taken as long as two decades to complete.

While nuclear power is an extreme case, similar trends are visible in other industries. The construction of a new semiconductor fab in Germany or the United States, for example, costs twice as much as building a fab in Taiwan, whereas equipment costs are the same globally.[42] In more standardized industries such as AI data centers, which are secure buildings with power and cooling systems to house racks of chips, the difference in construction time and costs is much narrower, with timelines for permits and licenses being the differentiator.

In our ten cases, project timelines are almost always longest in large European countries. In Germany, the average time for obtaining a nonresidential construction permit is roughly 200 days, compared with about 60 days in the United States, 40 days in Mainland China, and 30 days in India.[43] Timelines for operating licenses are similarly varied. In France, obtaining an operating license takes about 115 days, compared to about 20 days in the United States and about five days in Mainland China.[44] This absorbs management time and attention, with French managers reporting that they spend more than 20 percent of their time dealing with regulatory matters. These examples illustrate how institutional capacity to permit and deliver complex projects quickly can generate a competitive advantage in capital-intensive industries.

Equipment: Barriers to equipment trade drive cost differences between China and the United States in solar PV and data centers

Equipment is generally sourced on the world market and contributes little to cost differences. However, equipment costs become a key contributor to variation when lower-grade natural resources require more equipment to extract the same output, when plant designs differ, and when tariffs or trade restrictions come into play.

In the case of solar power, shipping costs and import tariffs on Chinese-made solar and battery equipment make levelized costs for a 95 percent “firmed” solar PV project, or a project designed to meet demand 95 percent of the time, in Texas in the United States about twice as expensive as in Inner Mongolia in China, despite comparable irradiation in these regions.

As for data centers, trade restrictions on leading-edge semiconductors have a material impact on Mainland China's data center costs and performance.[45] Our case focuses on colocation data centers, or "colos" as the tech industry calls them. In this model, investors fund the building shell and facilities, and the computing equipment is provided by users who rent space in the data center. In this model, energy is the primary cost driver for the data center player. By contrast, in the so-called hyperscaler model, the data center owner also owns the computing equipment, including chips. In this model, equipment costs constitute most of total costs and introduce a wedge between Mainland China and other markets. This is because export controls on leading-edge US graphics processing units require Chinese data centers to rely on less advanced imported or domestic alternatives. These consume significantly more power per rack and deliver lower performance, meaning that Chinese customers need to install more racks for the same amount of compute or accept lower performance, , which increases levelized cost per token by 30 to 35 percent at current levels of chip performance.

Labor: Labor costs for comparable roles differ by a factor of three or more, even though productivity in state-of-the-art facilities is the same across the world

Labor costs matter more than labor's factor intensity, or the extent to which it is used to produce a specific good or service, would suggest. Our research doesn't include classically labor-intense industries such as textile manufacturing and electronics assembly. Nonetheless, given the equalizing role of equipment and materials sourced on world markets, labor is the biggest source of variation in many capital-intensive manufacturing industries. Labor accounts for two-thirds of the 1.6 times cost gap in pharma manufacturing between the United States and China and for close to 50 percent of the 1.4 times gap in semiconductor fabs between Germany and Taiwan. In battery gigafactories, which require less specialized labor, labor explains more than 30 percent of the cost gap between China and the United States, and that excludes the labor cost differences embedded in construction capital expenditures.

Differences are also large in R&D-intensive investments such as in biopharma and automotive development projects. Labor represents about a third of development costs in automotive platform development R&D in China, compared to over 55 percent in higher-cost European countries and the United States, for biopharma the labor cost rises from a quarter of the total in China to 37 percent of the total for global players located in Europe or the United States. The differences in labor costs and labor productivity drive 50 to 80 percent of the substantial cost gap between China and its global competitors, with time to market and inputs explaining most of the remainder.

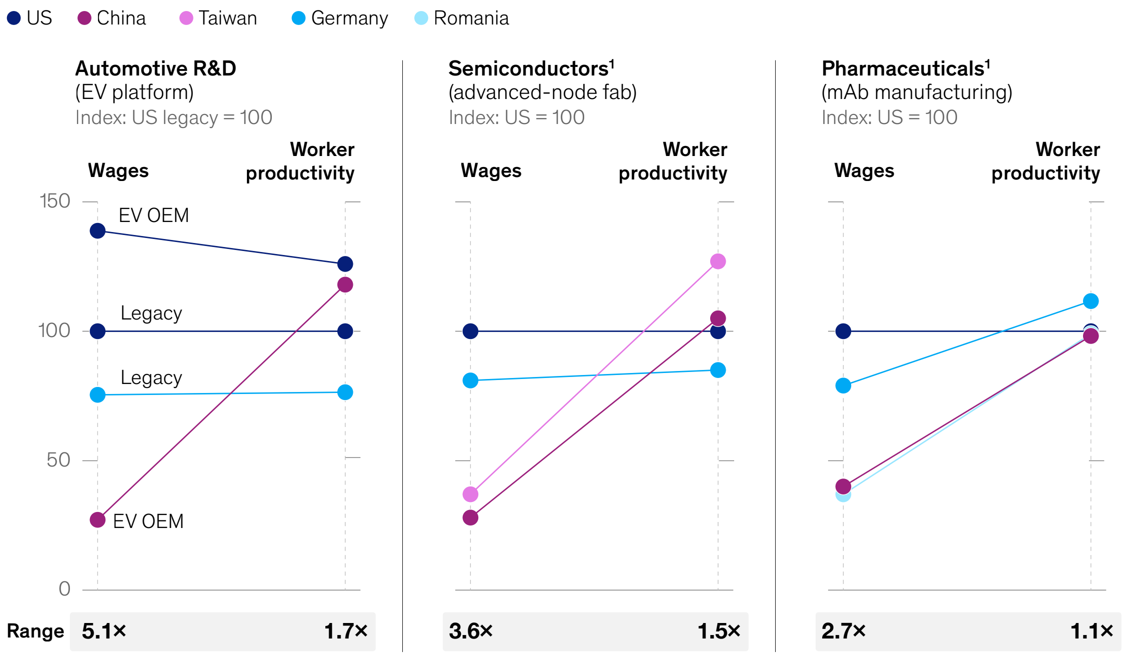
Labor costs in the United States and Western Europe are typically two to three times higher than in Mainland China and Taiwan and up to tenfold for blue-collar workers in steel production.

What may be more surprising to some readers is that this difference is no longer offset by higher productivity. Wages are determined by the overall economy of a country, but productivity is determined by the technology deployed at individual offices and factories, which is increasingly state-of-the-art everywhere. For instance, the output of a pharmaceutical plant in China and the United States is virtually identical, given that the same plant designs are used in both locations. But wages at US pharmaceutical companies are about three times higher than for comparable roles in China, creating a substantial structural cost difference despite comparable output (Exhibit 15). In advanced semiconductor fabs, Taiwan has both a cost advantage and a productivity edge over the United States. Taiwanese engineers achieve about one-quarter more output per worker despites wages that are roughly 2.5 times lower than their American counterparts'.

Exhibit 15

Wages in the United States are on average three times higher for comparable or lower output.

Wage per FTE and worker productivity, indexed



Note: Productivity is measured by unit output per FTE: % of platform output per FTE R&D EV platform; # mask layer per FTE×year for Semiconductors (advanced); mAbs production (kg) / FTE×year for Pharmaceuticals (mAbs manufacturing).

[1] Productivity differences show large dispersion across fabs; regional comparisons sensitive to sample composition.

Source: POBOS (McKinsey proprietary), McKinsey Global Institute analysis

McKinsey & Company

Energy: Costs are structurally higher in Europe's industrial heartland and Advanced Asia than in China and the United States

Each region has pockets of competitively priced energy. This is true not only in China and the United States, where industrial electricity users in the cheapest regions paid on average $50 to $55 per megawatt-hour in 2024, but also parts of Europe such as Scandinavia, where rates ranged from $40 to $65 per megawatt-hour.[46] Industry in China and the United States is largely clustered near this low-cost energy, having moved from early centers of industrialization: from the upper Midwest to the southern United States because of shale gas discoveries, for example, and from the Yangtze River Delta to Inner Mongolia in China, which has high irradiation and wind.[47]

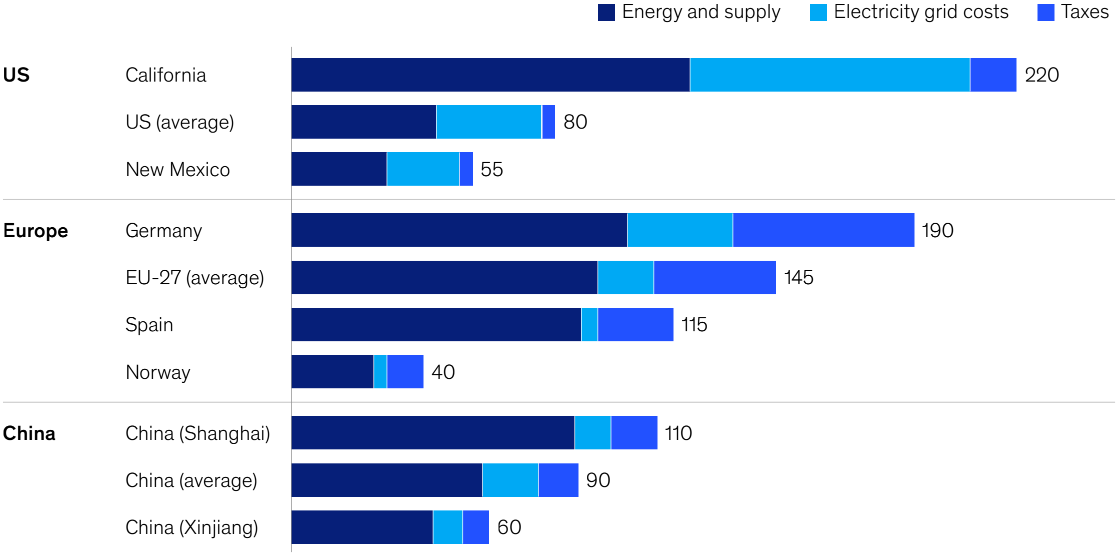
By contrast, most industries in Europe remain in the old industrial heartland around the Rhine and Rotterdam corridors, which formed around ample coal resources. Electricity in these regions now trades at an average of more than $150 per megawatt-hour, creating a drag on the competitiveness of energy-intensive industries. More recently, new capacity additions for power-hungry industries such as materials processing for batteries have been in Iberia and the Nordic countries, where electricity prices are cheap in comparison. But industry has not relocated to the extent it did in China and the United States, supported by national industrial policy. Japan, South Korea, and the United Kingdom also lack low-cost energy resources (Exhibit 16).

Among our ten cases, data centers and steel are examples of energy-intensive industries. Electricity prices explain almost 60 percent of the levelized cost gap of an colocation data center built in China compared to the United Kingdom. In steelmaking using the DRI—EAF process, energy, mostly in the

Exhibit 16

Europe’s industrial heartland has a structural energy cost disadvantage.

Industrial electricity prices, $/megawatt hour, 2024, including grid costs and taxes, excluding subsidies[1]



[1] Industrial electricity prices (Eurostat IG band, 150+ GWh, excl. discounts/exemptions) for Europe; EIA industrial average for US; NDRC provincial prices for China. Costs split into energy & supply, network, and taxes; for China, tax reflects VAT (13%) only, other charges are included in energy & supply. Norway shows range across bidding zones. Converted to $/MWh using World Bank average 2024 exchange rates.
Source: Eurostat; EIA; NDRC; KEPCO; ONS/DESNZ (UK); NordPool; McKinsey Global Institute analysis

McKinsey & Company

form of natural gas and to a lesser extent electricity, accounts for more than 90 percent of the cost differential between steel production in Oman and Sweden.[48] To offset this disadvantage, Germany and other European countries are currently subsidizing energy costs for heavy industry, sometimes by more than half the total cost, although the debate is also intensifying about shifting the most energy-intensive stages of production to locations with lower-cost energy.[49]

The levelized cost perspective in this research focuses on new, greenfield plants, but energy costs matter even more for existing, brownfield sites, where capex requirements for life extensions are lower and operating costs including energy become the main driver of competitiveness.

Materials: The United States has an advantage in fossil feedstocks and Mainland China in manufactured input materials.

Materials, being tradable, should theoretically be the great equalizer in investment cases. All companies can source inputs on world markets and should therefore pay similar prices, with any gap due primarily to transportation costs and tariffs. There are two important exceptions, however, related to feedstocks derived from natural gas and to dense supplier ecosystems for manufactured materials.

Natural gas and gas-derived products are important feedstocks that are not easily tradable where no pipelines exist. Prior to 2022, Asian, European, and US natural gas prices traded near parity. The war in Ukraine, however, stopped the flow of piped gas from Russia to Europe, and so markets in East Asia and Europe set liquefied natural gas (LNG) prices, which averaged roughly three to four times US prices from 2022 through 2025. They spiked again after the closure of the Strait of Hormuz in March 2026, to five times the US level (Exhibit 17). In addition to higher feedstock costs, gas-importing regions such as Advanced Asia and Europe are also much more exposed to price volatility.

For example, countries with ample natural gas resources such as Saudi Arabia and the United States can produce polyethylene by cracking ethane, a simple gas derivative. Countries without such resources rely on naphtha, which can only be transported by ship or in specialized pipelines. Germany, a historic stronghold for chemicals production, pays roughly double the cost to produce polyethylene as Saudi Arabia and the United States. The difference in feedstock prices and energy prices together explain roughly two thirds of this gap, with capital expenditure responsible for the remainder. The same challenge applies in other industries relying on inputs derived from natural gas, such as fuels and fertilizers.

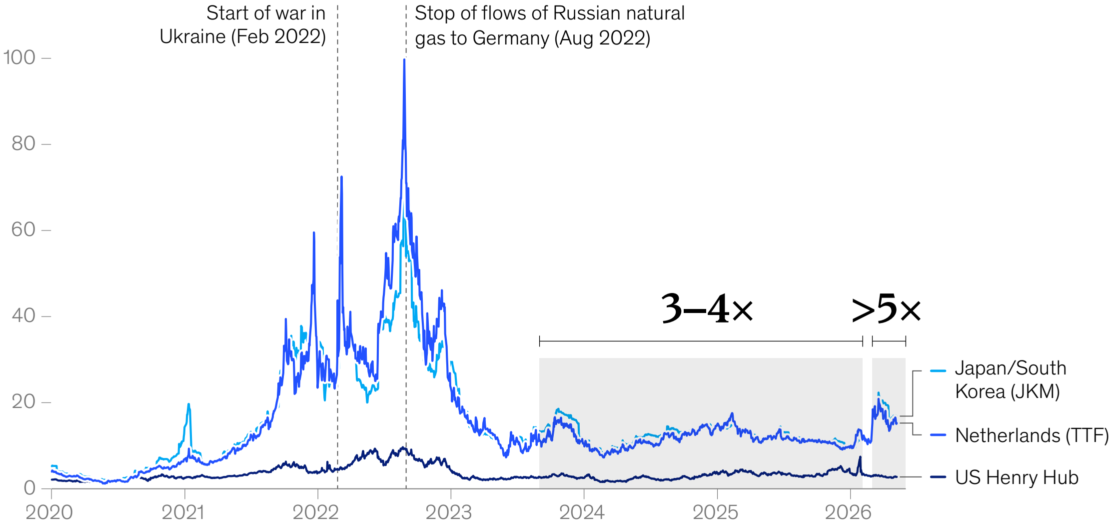
Large differences in feedstock prices help explain why even brownfield petrochemical investments are increasingly difficult to justify in Europe, and why the continent has lost close to 40 million metric tons of petrochemical production capacity since 2022.[50] While Mainland China also imports LNG, brownfield sites remain operational and even greenfield projects still proceed. In our calculation, lower capital and labor cost cannot make up for the cost difference in gas prices, meaning that Chinese operators may accept lower returns on their projects or receive public support of some sort.

Manufacturing industries such as batteries, semiconductors, and pharmaceuticals rely on manufactured products that are more easily transportable. Yet material costs are much lower in Mainland China thanks to its dense local supplier ecosystem.[51] Mainland China accounts for three-quarters of global lithium refining capacity, about 60 percent of nickel manganese cobalt (NMC) cathode active material production, and well over 90 percent of lithium iron phosphate (LFP) cathode active material production and graphite anode active material production.[52] This upstream dominance is reinforced by a deep base of equipment suppliers and gigafactory construction, which collectively reduce purchase prices, logistics costs, installation and commissioning costs, and learning-curve losses.

Exhibit 17

Gas prices around the world range from three time to more than five times higher than in the United States.

Natural gas prices, $/MMBtu[1]



Note: As of May 8, 2026.
[1] Million British thermal units, a standard unit of energy commonly used to quote natural gas prices.
Source: Bloomberg; CME Group; McKinsey Global Institute analysis

McKinsey & Company

In Europe and the United States, thinner supplier bases, smaller order volumes, and greater reliance on imported equipment and processed materials raise costs and increase exposure to volatility. Competitiveness in materials-intensive industries therefore depends not only on access to cheap energy but also on whether companies operate within dense, scaled, and integrated industrial ecosystems.

Time to market: Especially in industries with rapid innovation cycles and winner-takes-most dynamics, time to market matters

Speed affects project economics in several ways. For example, increasing management oversight or needing to rent a variety of equipment over the course of a project (which we quantify as part of construction costs) can increase project costs directly. Additionally, longer-duration projects reduce the value of a product in industries with rapid technical progress or limited patent durations, such as automotive and life sciences, as well as in industries with cyclical capacity constraints, such as semiconductor chips.[53]

In automotive, EV platform economics are propelled by major up-front R&D investments that must be recovered over a platform's lifetime. When development of an EV platform takes 36 to 48 months, which is common for legacy OEMs in advanced economies, revenues are pushed further into the future and discounted more heavily. In Mainland China, establishing such a platform takes 21 to 28 months, and revenue starts rolling in much earlier because EV companies have simpler portfolios and faster ways of working (Exhibit 18). A later launch also limits the period during which a platform can generate full-margin sales before its technology is superseded by, say, electric vehicles with longer ranges or more advanced driver assistance systems. In this analysis, speed explains 10 percent of the substantial cost gap between a legacy American automotive manufacturer versus an EV-only player in China. If we excluded structural factors beyond the control of an individual manufacturer, such as wages and working hours, the share of the cost gap linked to time to market increases to one-third, making it the most important competitiveness driver within a manufacturer's control.[54]

In biotech, so-called fast-following Chinese companies can launch drugs roughly two years earlier than firms in Europe and the United States, where a 13-year development cycle is typical. This preserves more of the remaining patent life and thus extends the period in which to generate revenue.[55] Time to market is one of the key drivers of the levelized cost gap in biotech R&D, explaining almost 40 percent of the total difference. In the case of pharmaceutical manufacturing, time plays a smaller role because production can be outsourced to contract manufacturers while a company gets its own plants up and running, thus avoiding loss of patent lifetime.

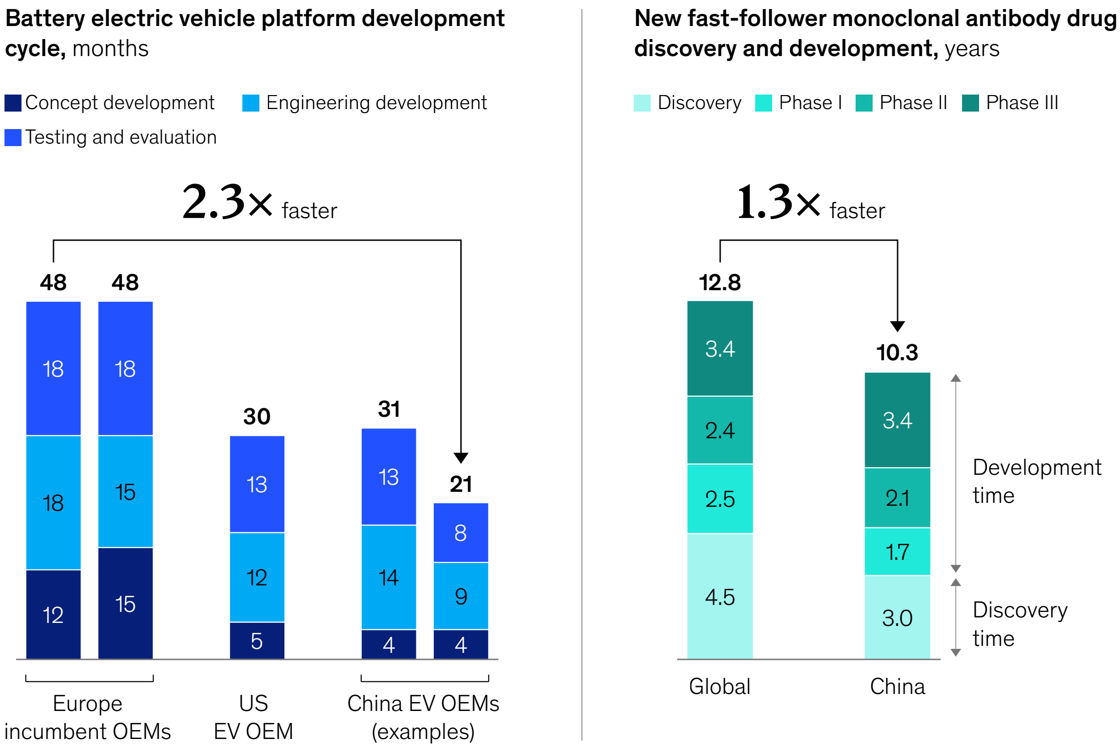
In datacenters, speed of execution has become the primary concern. AI frontier labs and hyperscalers face labor shortages, equipment lead times, permitting delays, and grid queues driven by the AI boom. Lead times to obtain key components such as generators, chillers, transformers, and switch gear have more than doubled since 2019, and some markets have waiting of up to a decade. In the case of AI training datacenters being built by hyperscalers, a one-year project delay can be the equivalent of doubling in electricity costs due to postponed revenues and changes in the pricing environment.[56]

In semiconductors, prices per wafer are far higher when a node is still at the technological frontier and fall steadily as it matures and new entrants arrive, meaning that faster time to market has a direct impact revenue potential. As revenue and pricing effects are not part of the levelized cost methodology, this is not modeled in the waterfalls. Had we analyzed leading-edge or memory chips rather than 28-nanometer fabs or AI data centers driven by scarcity pricing, for example, time to market would have played a major role.[57]

It is important to note that speed also matters when it doesn't show up directly in the line items of an investment case. This is because long lead times can limit the ability to capture market opportunities, absorb too much management attention, and conflict with shorter-term corporate growth objectives. As innovation cycles accelerate across many industries, speed is becoming more important.

Exhibit 18

Chinese companies are speeding up the R&D cycle.



Battery electric vehicle platform development cycle, months

New fast-follower monoclonal antibody drug discovery and development, years

Source: S&P Global Market Intelligence; McKinsey Global Institute analysis

McKinsey & Company

Financing costs: Financing costs are similar for global corporations in advanced economies and China, but add to costs in developing countries
Across Advanced Asia, China, Europe, and the United States, the weighted average cost of capital reported by listed companies varies more by industry than by region.

Examining the ten industries in this research, the weighted average cost of capital (WACC) in those countries range from 4 to 7 percent in anchored industries, like nuclear and solar; 7 to 8 percent for footloose industries, such as steel and polyethylene; and 8 to 10 percent for arena industries, like automotive R&D and advanced semiconductor fabs. This reflects that risks to investors are lowest in mature industries with contracted or protected revenue and highest in industries that are exposed to multiple overlapping risks in technology, operations and demand.[58]

It may be surprising to some that Chinese financing costs are closely in line with those reported by Western corporates. Companies in emerging markets typically report higher capital costs than in advanced economies, given higher governance and political risks. In China's case, such risks may be canceled out by greater access to state-backed debt financing that compresses debt costs. This effect is compounded by sample selection: Listed Chinese companies are disproportionately large, state-adjacent firms, making them more comparable to blue-chip Western corporates than to the broader Chinese corporate universe or Western joint ventures operating in China.

While there are no systematic differences between advanced economies and China in our sample, there are major differences in WACC for emerging and developing countries. Solar PV is a clear example of this: China's WACC is 4 percent, versus 6 to 7 percent in India and Brazil. The difference in financing costs affects levelized costs in capital-intensive industries directly. For instance, financing costs account for half of the difference in solar PV costs between India and China.

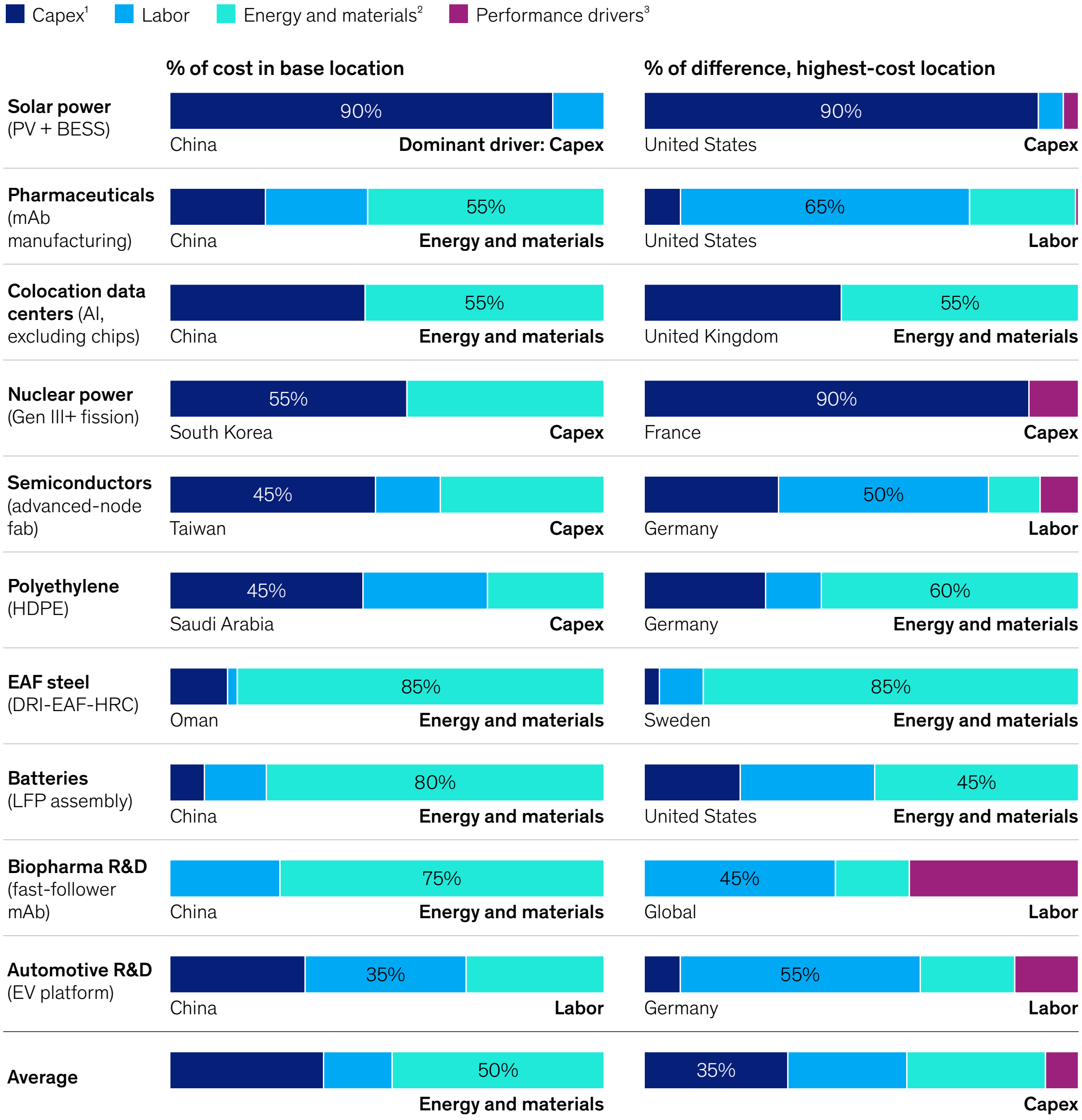
The biggest cost driver is not always the biggest determinant of cost competitiveness

In about half of our cases, the primary cost driver in the base-case location does not determine the difference in costs between countries. Taking a simple average of our ten industries, capital expenditures account for close to 45 percent of costs in the base-case location, and energy and materials an additional 40 percent. Looking at the difference between the highest- and lowest-cost locations, however, capital expenditures explain less than 30 percent of the difference, while the role of labor doubles to 35 percent, and performance drivers such as speed and scale introduce a wedge of almost 10 percent between highest- and lowest-cost locations (Exhibit 19).

Exhibit 19

The primary cost driver is not always the primary driver of variation between countries.

Decomposition of cost drivers between base case and highest-cost location, % of total



[1] Includes construction and equipment costs.
[2] Includes energy, materials, and other opex costs (e.g., outsourcing in the Biotech R&D case).
[3] Includes time to market and country risk costs.
Source: McKinsey Global Institute analysis

McKinsey & Company

A more competitive levelized cost often signals higher investment intensity, although other factors matter

In almost all industries, countries in our sample with lower levelized costs have the highest investment intensity compared to their GDP, while countries with higher levelized costs invest less (Exhibit 20).

Exhibit 20

Cost is a good predictor of investment – with important exceptions.

Levelized cost versus investment intensity indexes by selected industry, base-case country = 1

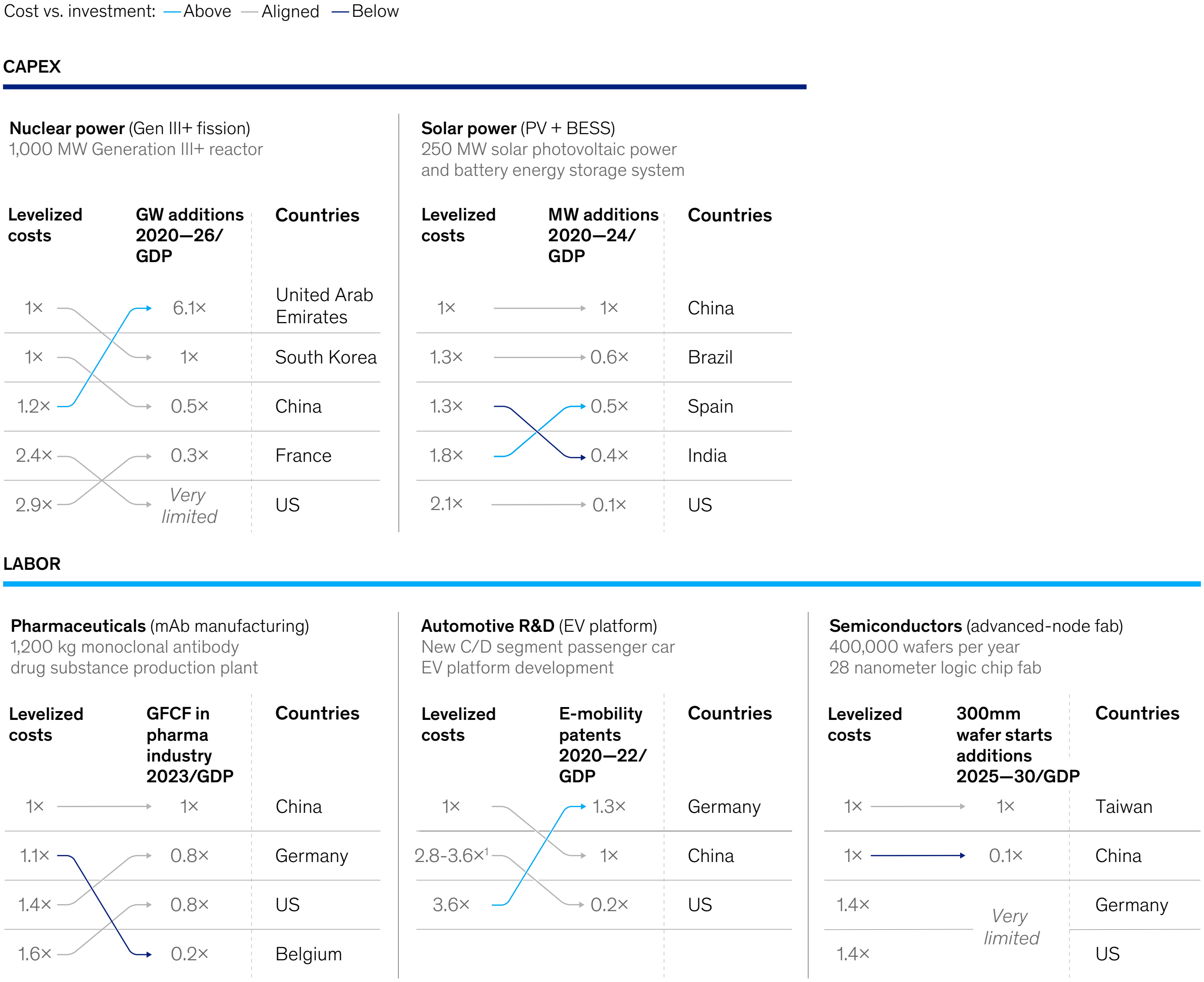
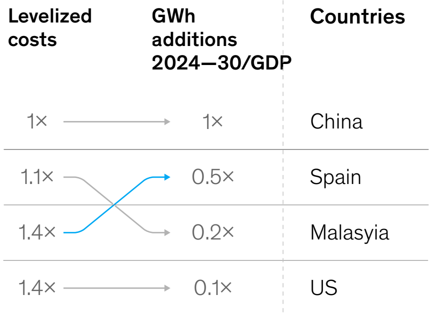


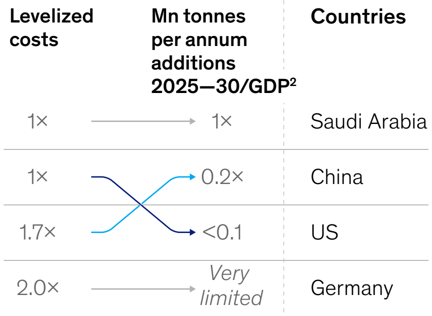
Exhibit 20 (continued)

MATERIALS

Batteries (LFP assembly)
50 GWh lithium iron phosphate gigafactory

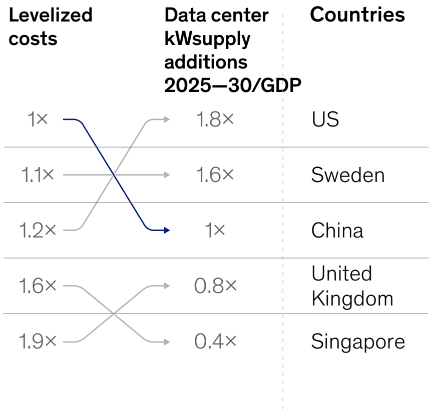


Polyethylene (HDPE)
1 million metric tons per year of ethylene capacity feeding a 400,000 metric ton per year high-density polyethylene unit

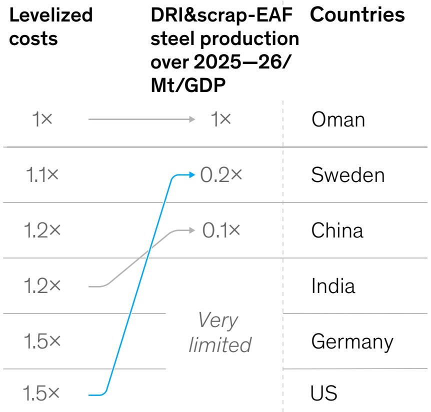


ENERGY

Colocation data centers (AI, excluding chips)
100 MW colocation data center, excluding chips

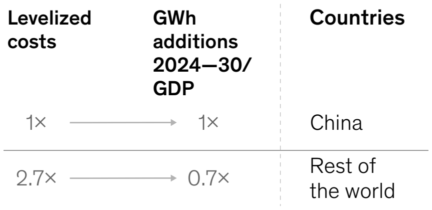


EAF-steel (DRI-EAF-HRC)
2.5t hot-rolled coil flat steel from direct reduced iron-electric arc furnace plant



TIME

Biopharma R&D (fast-follower mAb)
New fast-follower monoclonal antibody drug discovery and development



Note: Levelized cost is before taxes and direct subsidies.
[1] Range represents legacy OEMS with EV platforms and EV disruptors.
[2] Regional proxies used where country-level data is unavailable; regions include North America, Middle East, and Western Europe.
Source: International Energy Agency; International Renewable Energy Agency; International Atomic Energy Agency; World Nuclear Association; OECD; S&P Global Market Intelligence; Oxford Economics; SEMI; La Moncloa; Malaysian Investment Development Authority; McKinsey Global Institute analysis

McKinsey & Company

To be sure, the many exceptions to this general rule highlight the importance of other factors that have a role in investment decisions. Markets and ecosystems, as well as fast permitting and building, explain why Singapore builds more AI data centers than its high energy prices would suggest, while Sweden builds less than it could, given its competitive energy costs. Similarly, Germany remains the biggest investor automotive R&D compared to its GDP, despite China's significant cost advantage. AI data centers and EV platforms are examples of arenas in which ecosystems and speed matter most. Economic geography research suggests that it is extremely hard to manufacture new ecosystems[59]—but as the example of Shenzhen, China, shows, even complex ecosystems can be recreated if the fundamental economics warrant it.

Industrial policies including subsidies and regulations enable Germany to build more solar energy, the United Arab Emirates to build more nuclear plants, and China to build more polyethylene crackers than their relative cost position would suggest. Nevertheless, business cases clearly are critical for the long-term viability of an industry as well as for the amount of taxpayer money needed to close gaps with industrial policy where that is intended.

Having established the extent of variation in levelized costs in investment cases, we next turn to what companies and governments lagging in investment could do to make themselves viable again.

CHAPTER THREE

What it would take to rebuild competitiveness

In the past, different endowments allowed different economies to be more competitive: cheap labor here, cheap energy there, innovation strength or deep capital markets with low financing costs elsewhere. Today, some countries—China chief among them—have unusually large advantages across an unusually broad set of production factors, resulting in a lead in almost all the investment cases we studied (see sidebar "China: Low macro productivity, high micro productivity"). This shrinks the space for specialization in other large economies and means that narrowly targeted responses will be insufficient to overcome the large cost differences. In this chapter, we map out some possible pathways to restore competitiveness (Exhibit 21).

Sidebar

China: Low macro productivity, high micro productivity

China still has a productivity disadvantage at a macroeconomic level, measured in GDP per hour worked and GDP per unit of capital employed, as described in Chapter 1. However, this is not true at the level of individual industries, since global companies build comparable state-of-the-art facilities everywhere. Standardized technology and processes narrow or eliminate productivity differences, as the investment cases we analyze show.

High adoption of AI and robotics is further narrowing the gap, or indeed increasing China's edge. China trails many advanced economies in average robot density, but it is catching up rapidly. In 2024, China had 166 industrial robots per 10,000 manufacturing employees, compared to 204 in North America, 267 in western Europe, and 1,220 in South Korea.[1] China now installs more industrial robots than the rest of the world combined.[2] In individual factories, again, the level of technology deployment may even exceed that in other regions. There are reports of "lights-out factories" that are fully automated, round-the-clock manufacturing facilities operating with little human presence, lights, or heating, supported by AI and robots.[3]

Similarly, Chinese companies in many cases lead on R&D and speed of new product launches, as we have seen in our investment cases. This enables them to provide new, improved, and more affordable goods to the world but also exacerbates the competitiveness challenge.

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[1] "Robot density surges in Europe, Asia, and Americas," International Federation of Robotics, April 8, 2026.

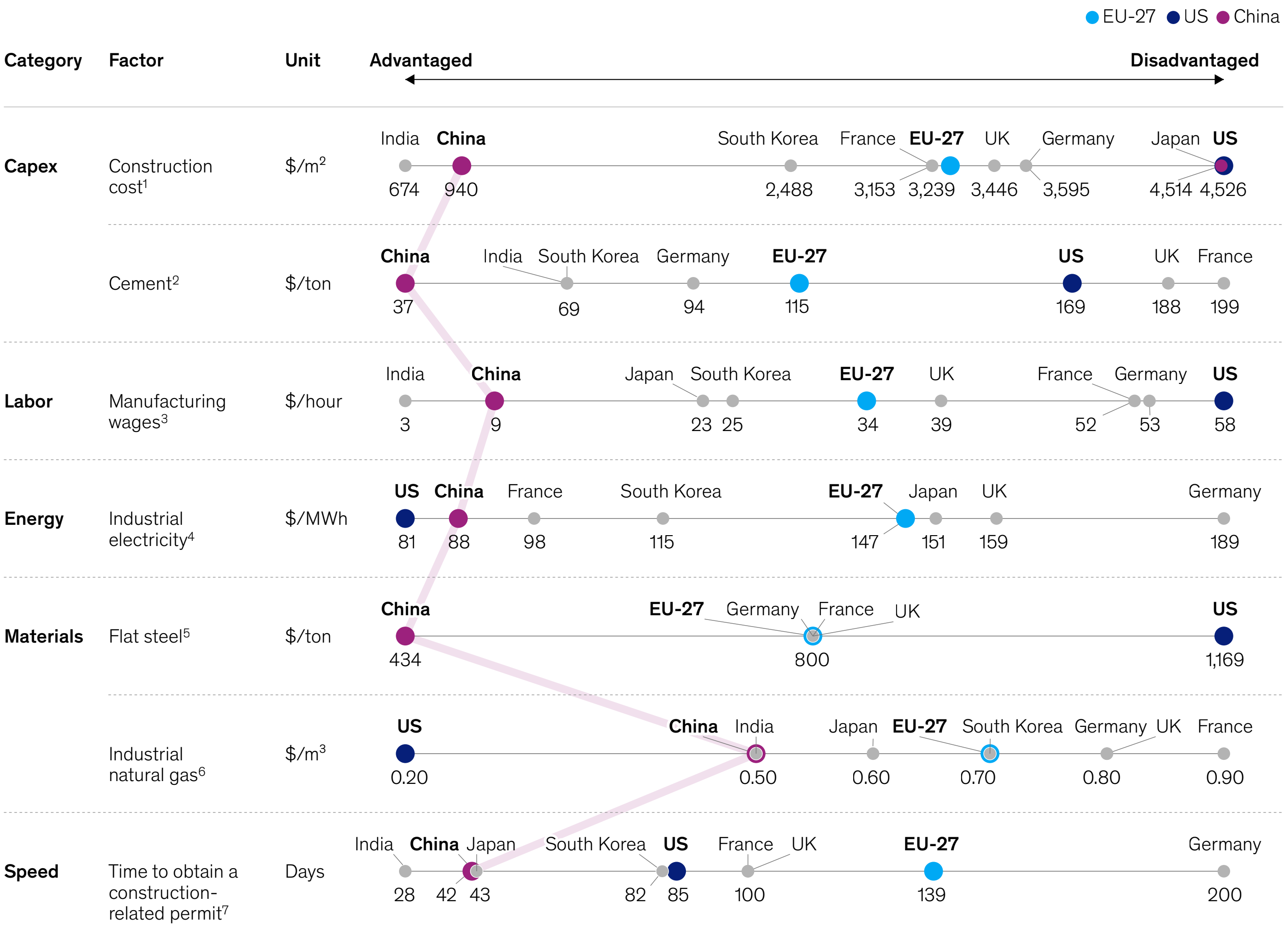
[2] "Executive summary," in *World robotics 2025 industrial robots*, International Federation of Robotics, 2025.

[3] Ksenia Shaikhutdinova, "Inside China's dark factories where robots run the show," *Wall Street Journal*, July 18, 2025.

Exhibit 21

China has an advantage across most factors of production.

Selected cost factor distributions across major geographies



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[1] Typical direct construction cost per square meter, average of benchmark cities in country, reflecting labor, materials, equipment, overheads, and local market conditions, Turner & Townsend, 2025.
[2] Factory gate cement price, CemWeek, CW Group, Q4 2023.
[3] Fully loaded hourly manufacturing compensation including direct pay, bonuses, benefits, and labor taxes, Economist Intelligence Unit, 2025.
[4] Electricity prices for industrial users consuming 70,000–150,000 MWh; including generation cost, network cost and taxes, excluding indirect cost compensation or other subsidy schemes, SNL, Eurostat, Bank of Japan, 2024
[5] Hot-rolled band transaction prices, volume weighted, SteelBenchmarker, May 2026.
[6] Natural gas pricing for industrial users, including non-recoverable taxes and network charges, excluding recoverable VAT, IEA, DESNZ, Eurostat, CEIC, Gujarat Gas, 2024 or latest available.
[7] Calendar days from completed application to approval, covering construction, expansion, and building permits; EU-27 reflects average of available member states, World Bank, 2025.

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A step change in production factors would be needed to bridge half of the cost gap with best-in-class countries

Europe was successful in the industrial age, thanks to high degrees of automation that compensated for higher labor costs, quality leadership in manufacturing, and competitive energy costs, but those advantages are eroding. The United States long accepted large imbalances in manufacturing, instead focusing on technology and services in which it leads globally, although it is now working to address import dependencies. For its part, China has arguably been *too* successful in manufacturing industries and now struggles with excess capacity, low capital returns, internal and external imbalances, and a need to sustain growth through domestic demand.[60]

All regions will have to step up to achieve their stated goals. To gauge what it would take to restore cost competitiveness, we ran a directional what-if scenario on the input factors in the ten investment cases. This exercise was an attempt to determine what combination of changes could make these investment cases viable again in advanced economies. It is not a prediction of what will or even should happen.

First, our assumptions:

- For capital expenditures, we assume that half the current gap in construction cost and time would be closed, as would the entire gap in equipment costs. We do not assume full convergence of construction costs because part of the gap reflects structural differences in labor cost structures and standards. We do assume that permitting reform, modular construction, greater standardization, and stronger delivery practices could narrow the gap materially without compromising social and environmental standards.
- For materials, we assume that half the current gap in material cost could be closed by deploying innovative materials, leaner lower-waste processes, and new production technologies. However, fully closing the gap is unlikely due to geography and access to raw materials—for example, steel and polyethylene would see no cost reduction.
- For labor, we assume a step change in productivity of about 30 percent related to broader adoption of AI, automation, and better operating models. We also assume a 10 percent reduction in overall labor cost by, say, reducing social contributions and related nonwage charges through reforms in financing or by making it easier to restructure companies.
- For energy, we assume a sharp reduction in gas and electricity costs in Europe to levels more similar to those in China, which has managed to deliver competitively priced energy through a different system architecture despite a lack of natural energy resources.
- For time to market, we assume a level playing field, reflecting the fact that companies in advanced economies could theoretically move at speeds already achieved in China, as leading disruptors across industries have demonstrated.

A coordinated push across all these factors could close 50 to 70 percent of the cost gap in the United States compared to best-in-class locations and roughly 30 to 60 percent of the gap in Europe. This could bring many investment cases materially closer to viability.

Beyond cost, companies and countries could innovate, specialize, and level unlevel geographic playing fields

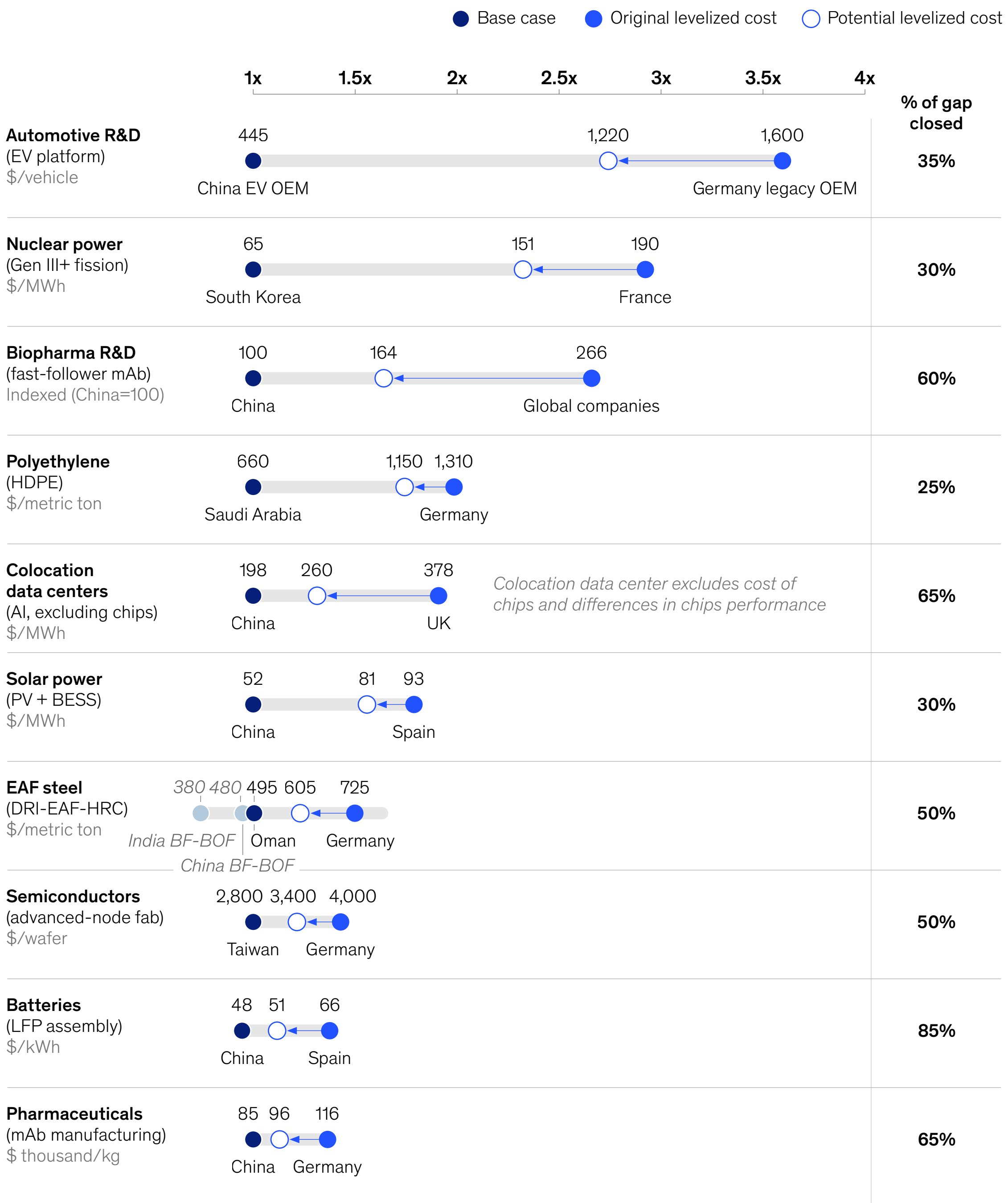
Even heroic assumptions about achieving these goals do not translate to sufficient change to fully close the gap, however (Exhibit 22). To escape pure cost competition, companies and policymakers could work by regaining innovation leadership and specializing in differentiated goods and services that play to a country's strengths or can sustain premium pricing that offsets higher costs.

Exhibit 22

A coordinated push on competitiveness could close a significant portion of the gap to the lowest-cost producer.

Levelized cost improvement potential, before taxes and direct subsidies

Europe



Source: McKinsey Global Institute analysis

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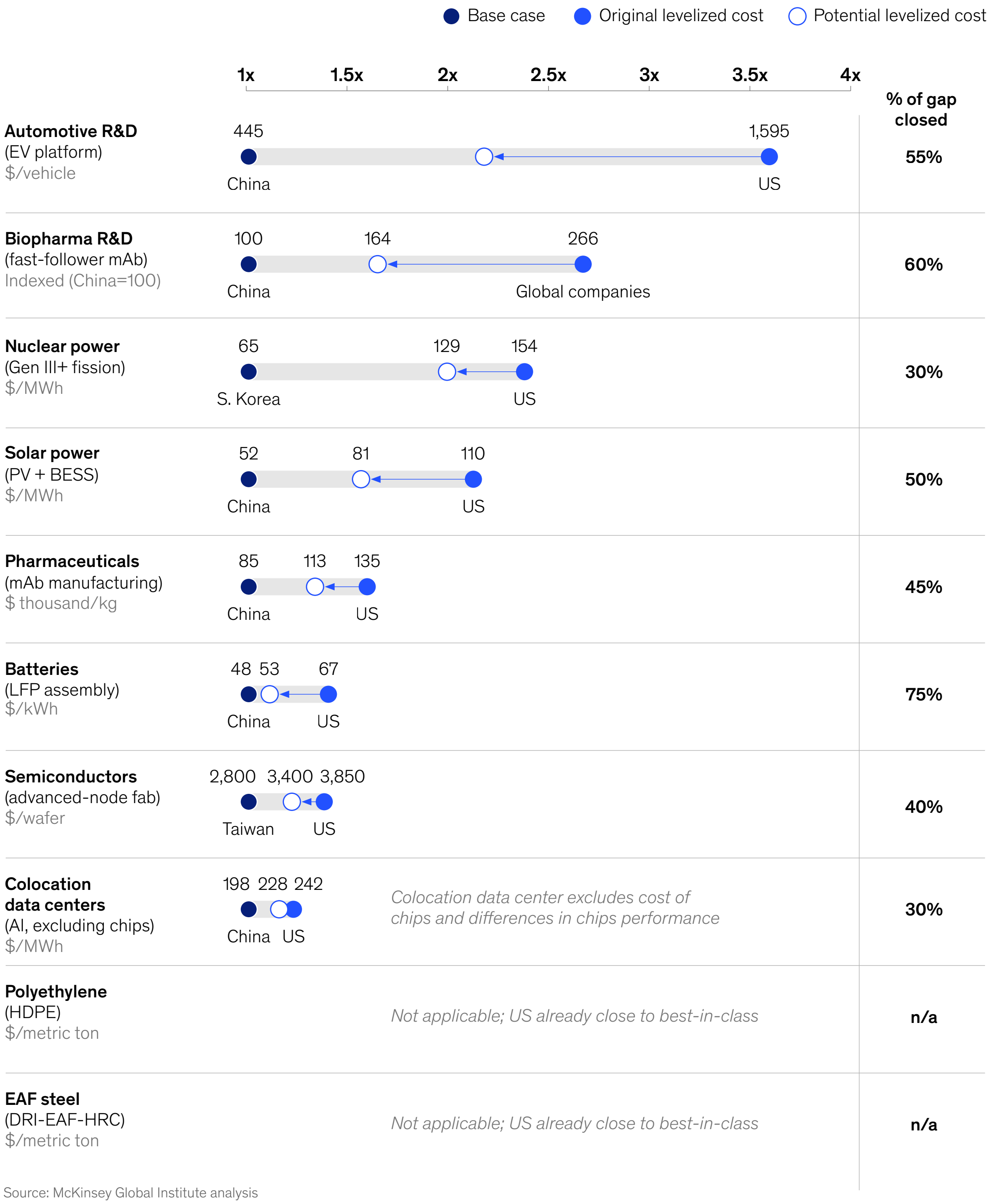
Exhibit 22 (continued)

A coordinated push on competitiveness could close a significant portion of the gap to the lowest-cost producer.

Levelized cost improvement potential, before taxes and direct subsidies

United States



Source: McKinsey Global Institute analysis

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Where the gap remains too wide to achieve a country's aims, macro-level interventions could level the playing field. Such intervention could include reducing exchange rate distortions, using selective trade policy, deploying industrial policy, and renegotiating any policies that currently tilt the global balance in investment.

Until competitiveness is restored, navigating today's unlevel playing field will require companies to think through tough trade-offs between investing where costs of production are low, ensuring supply chain resilience, and achieving longer-term competitive goals. Understanding the lessons offered by the lowest cost and best-in-class locations today can raise competitiveness everywhere.

The alternative option to deal with differences in competitiveness and levelized cost is, of course, to simply accept them, along with the trade deficits—and surpluses—that come with them (see sidebar "What is the alternative to restoring competitiveness?")

Sidebar

What is the alternative to restoring competitiveness?

Countries can, in principle, tolerate sustained trade and investment imbalances rather than trying to eliminate them. In practice, this means accepting that some economies will continue to run large surpluses in the production of tradable goods while others absorb those goods through persistent trade and current account deficits. This is not a theoretical edge case. It has already been a defining feature of the global economy for decades, particularly in the relationship between the United States and major surplus economies.

It is also not, per se, a bad or unsustainable choice. Persistent imbalances align well with the intertemporal nature of trade. For instance, aging economies have excess savings and thus also trade surpluses, while comparatively young and dynamic economies import more. Economies with a trade surplus benefit from a capital buffer that can be drawn on in times of stress, as repeated "sudden stops" in global finance such as the Asian financial crisis have demonstrated.

Deficit economies benefit from low-cost imports that also benefit consumers and improve the competitiveness of domestic producers using them, as well as from low-cost financial inflows that lower the cost of capital and support asset prices and domestic wealth. Advanced economies in particular can benefit from deficits because service sectors, from finance to telecom, are far more productive than the components of manufacturing that are typically offshored. In fact, the offshoring wave that swept the United States in the early 2000s provided a strong tailwind for national productivity. Current account deficits can be sustained without net foreign liabilities spiralling out of control so long as they don't exceed nominal GDP growth rates.[1]

Yet imbalances also come with costs. For deficit countries like the United States, a loss of manufacturing jobs and pressure on wages can be problematic in certain regions even as the overall economy benefits. A loss of production capabilities in strategic value chains or a failure to build them in the first place can become an issue for strategic autonomy and defense. Countries that tolerate prolonged deficits may find that they still excel in design, finance, and research but lack the industrial depth needed to scale production quickly in times of stress. This concern is especially relevant in the context of this report's argument that today's investment shapes tomorrow's production footprint.

Countries with trade surpluses also carry costs and risks. These can include loss of global purchasing power relative to higher real effective exchange rates; starved domestic consumption as resources are disproportionately allocated to exports; financial risks if accumulated foreign reserves are devalued or otherwise impaired; and internal or external pressure to expand domestic demand.[2]

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[1] Note that while some contend that US net foreign liabilities over the past five to ten years have followed a path that is unsustainable, this pattern is linked to the outperformance of the US stock market, because US equity liabilities rise faster than US equity holdings abroad regardless of trade imbalances.

[2] Martin Wolf, "Why global imbalances matter," *Financial Times*, May 13, 2026.

Countries seeking to catch up with global investment leaders can push or pull seven levers

Restoring balance to investment around the globe requires more than simply addressing cost differences. Companies and countries can deploy seven levers to level the playing field, though the mix of levers will vary across regions depending on the domestic context and geopolitical priorities.

Capital expenditures: Release the brakes and industrialize construction

Capital expenditures play a decisive role in decisions to invest in infrastructure and energy projects such as nuclear power plants and solar PV. They also play an important role in capital-intensive manufacturing industries, including batteries, semiconductors, pharmaceuticals, and data centers. In the industries we analyzed, construction timelines and costs in the United States and Europe are often substantially higher than in many Asian countries. For example, semiconductor fabs can cost almost twice as much to build in Germany and the United States as in Mainland China and Taiwan, and recent nuclear plants in advanced economies have come in at roughly three times the cost of the latest projects in South Korea.

A meaningful share of these gaps is explained not only by higher input prices but also by how projects unfold. Comparing advanced economies and China, a large part of the gap reflects lower capital delivery efficiency rather than more expensive labor, steel, cement, or equipment. In other words, part of the disadvantage comes not from what advanced economies build with but from how they build, which is shaped by slower permitting processes, longer development cycles, more bespoke engineering, and less learning from one project moving to the next.

By removing friction from the construction phase, governments could materially reduce cost and construction timelines without compromising high environmental or social standards.[61] By streamlining approvals and inspections across multiple agencies—for example, by standardizing documentation and centralizing submission processes—building timelines can be shortened. Adequate staffing, training, and use of AI in document review can lead to material acceleration.[62] Preapproving sites and putting in place infrastructure can further shorten project timelines.[63] Advanced economies have shown that they can move much faster when urgency is high. For example, Germany's new LNG import terminals began operating 200 days after the war started in Ukraine thanks to fast-tracking permitting and deploying modular floating infrastructure.[64]

Companies can build faster and at lower cost by adopting proven tactics already used at scale in various markets. Reusable blueprint designs, modular construction, and prefabricated units can cut the costs of bespoke engineering and speed up on-site assembly. In the United States, for example, data center developers are increasingly using scalable reference designs, modular construction, and off-site assembly to accelerate project completion by as much as 50 percent, reducing capital spending by 10 to 20 percent on average.[65] Commercial incentives in contracting that link directly to delivered output and project progress can also increase motivation to improve productivity by minimizing paid-to-wait time and cost overruns.

Advanced economies retain strengths in construction such as complex engineering, stringent quality assurance, and high safety standards that result in assets with tight tolerances and reliable long-term performance. The challenge is to combine those strengths with faster, more repeatable, and more industrialized delivery.

Labor: Push the productivity frontier and lead on AI deployment

Labor policies in advanced economies differ from those in emerging economies, and overcoming those differences is challenging. Theoretically, wages or prices in China could increase in tandem with the productivity of its workers. The alternative, letting wages fall in advanced economies, is neither desirable nor feasible. The only way to narrow gaps in labor costs is to achieve step changes in productivity in advanced economies with technology adoption, process redesign, and workforce upskilling. However, state-of-the-art factories are similar around the world, so these steps alone will not guarantee a lead. If US semiconductor fabs achieved Taiwan-level productivity, for instance, it would close 10 percent of the gap with Mainland China.

Reinventing production processes with AI and advanced automation could increase worker productivity, promote faster development of better products, and help companies grow.[66] At this point, however, the share of businesses identifying AI as key to transforming their organization is larger in China than in any other major economy.[67]

Policy change could support businesses seeking greater labor productivity and lower labor costs. For one thing, policy could have a direct impact on the cost of hiring employees by amending which costs are borne by employers and employees. In Europe, nonwage costs and payroll taxes such as social security contributions range from less than 5 percent in Romania to more than 30 percent in France. Second, policy has a direct impact on labor market flexibility. In Germany, restructuring costs are high and dynamism limited, which weighs on productivity compared to countries such as the United States with more flexible employment policies.[68] Denmark's flexicurity program—which allows employers to dismiss workers in response to changing market conditions while also providing workers with a safety net between jobs and supporting rapid reintegration into the workforce—is an example of an alternative in Europe.[69]

Energy: Secure abundant, competitive, clean energy and locate heavy industry near energy sources

Energy is a decisive factor in competitiveness, and energy costs differ significantly between regions depending on their resource endowments.[70] Oil is easy to transport and trades at near-global parity, but gas prices diverge structurally. Regions lacking connection to gas pipelines pay three to four times more to cover the costs of liquefying and shipping LNG, which also influences electricity prices.[71] Historically, this was a challenge primarily in Asia, but after the collapse of Russian pipeline gas supplies in 2022, also in Europe's industrial heartland.[72] Disruptions such as the recent US-Iran conflict further exacerbated this gap. For example, gas prices in Europe and Japan were roughly 50 percent higher than before the outbreak of the conflict in May 2026, but US natural gas prices were 25 percent lower than the average price in 2025, a reflection of plentiful domestic supplies.[73]

In the near term, LNG-dependent countries in Europe and Asia could secure LNG and piped gas from more diversified sources, increase biomass and biogas use, extend the life of nuclear reactors, and accelerate electrification by building the required transmission and storage infrastructure as well as by promoting demand-side flexibility measures. Some countries are also considering deferring the phase-out of coal generation.[74]

However, countries cannot become energy competitive when relying on LNG that is structurally at least twice as expensive as piped gas, and solar power that is only half as efficient as in sunnier regions.[75] Structural options for Europe's industrial heartland and other energy-disadvantaged regions include building additional gas pipelines, developing domestic shale gas, and deploying nuclear reactors, while also accelerating long-distance grid interconnections and shifting parts of industry to regions with structurally lower electricity costs. Many power-hungry projects are already under construction in the Nordics and the Iberian Peninsula rather than in the Rhine-Ruhr valley that would traditionally attract such industries in Europe. Governments could accelerate and support such a shift by facilitating transformation and developing new, competitive activities rather than cementing the status quo through subsidies.

Innovation can also help overcome disadvantages in energy and materials access. For example, novel solid-state battery technologies could reduce the cost gap relative to the established lithium-ion value chain in China. Similarly, nuclear fusion, if achieved, could address issues arising from fission production. While neither success nor sustainable competitive advantage is guaranteed, thinking outside the box and investing in experimentation and engineering can increase competitiveness.

Time to market: Step on the accelerator and remove regulatory complexity

As innovation cycles accelerate and competition heats up in tech-intensive industries, speed has become a core determinant of competitiveness for companies and countries. This is particularly true in the important arenas of competition, where innovation execution can make or break a business case, as well as in capital—intensive industries in which a large share of the gap in construction costs between countries is linked to speed or delays. Since many businesses in advanced economies are multinationals with global footprints, their strategy includes opting for the most competitive locations for getting things done whenever possible. If one place requires six months more to secure approvals for new products or a permit for building a production facility, all else being equal, companies will invest where they can move faster. Similarly, if starting a new business or restructuring an old one is too slow or expensive, investments will move elsewhere.

Regulatory reforms could enable companies to move faster; especially, in Europe, where regulatory barriers are highest.[76] Yet most companies could speed up on their own by compressing product-development cycles, shortening capital-project schedules, and reducing the time needed to move from concept to scale. R&D, for example, could embrace iterative ways of working and parallel development processes. If German automotive companies replicated key elements of the Innovation Execution operating models used in Chinese automotive manufacturing, they could reduce development timelines by more than half, effectively decreasing their levelized costs by 25 percent. American EV disruptors are an example of companies that successfully operate in this way, even in a market where other automotive manufacturers don't.

Innovate and differentiate to avoid competing on costs alone

In many industries, even heroic efforts to narrow the gap in levelized costs will not level the playing field. Companies in these industries could nonetheless invest profitably in Europe and the United States, where they can sustain higher prices because of performance advantages, customer proximity, and brand recognition and trust. Even bulk commodities industries such as polyethylene often offer distinct performance profiles that limit direct substitution between suppliers; prices of advanced semiconductor chips differ by up to 30 percent depending on where and by whom they are manufactured.

An effective way to secure a premium is to offer a product competitors cannot match in quality or in specifications. This requires innovation. For example, complex pharmaceutical therapies command higher gross margins than traditional small-molecule drugs because they are harder to develop and replicate, giving manufacturers pricing advantages and effective commercial exclusivity windows of ten to 14 years after regulatory approval. Factors such as customer proximity, brand recognition, and trust can further strengthen such an advantage for producers.

AI may turbocharge the processes companies use to develop and provide new products. It is accelerating everything from software development to new drug discovery and is changing how companies interact with their customers. This could lead to faster product development cycles, improved products, and ultimately stronger pricing advantages for companies that are early adopters, affecting global competition especially as access to frontier models becomes less universal.[77]

Policy can enhance or hinder domestic producers' capacity to innovate. Recent MGI research highlights the factors underpinning so many successful US inventions, including a favorable environment for foundational and applied research as well as for commercializing innovation.[78] Increasing innovative capacity is even more urgent in Europe, which has been successful in creating ideas but less successful in scaling and deploying them. Previous MGI research with the World Economic Forum laid out important public-sector reforms to strengthen Europe's innovation and investment environment for future technologies (see sidebar "How Europe can strengthen its innovation position in future technologies").[79]

Sidebar

How Europe can strengthen its innovation position in future technologies

In addition to preserving today's premiums in current industries, companies will need to win in the next big arenas of competition.[1] US companies currently lead in 14 of these 18 arenas by market capitalization and in ten by revenue, while Chinese firms lead in three by market capitalization and five by revenue. European firms lead in one arena on both measures. As technology grows more contested and different countries create explicit chokeholds in certain technologies or value chain steps, Europe will need to find its answer.

While Europe cannot lead in all technologies, MGI's previous work with the World Economic Forum laid out a pathway Europe could follow to increase innovation in 14 significant technologies based on strategic importance, maturity, and the continent's starting point.[2] Taking the following steps could improve competitiveness on the continent:

- Cement leadership in mature technologies in which Europe already has a leadership position, including parts of semiconductor equipment, industrial machinery, advanced connectivity, and pharma manufacturing. The goal is to reinforce scale, protect ecosystems, and create demand for European products.
- Reach maturity and commercialize quickly in nascent technologies in which Europe is well positioned to lead, such as quantum, climate tech, advanced materials, and bioengineering. The focus would be on speeding commercialization, scaling promising applications, and building lead markets.
- Pick battles and leapfrog in nascent technologies in which Europe is currently lagging, such as AI, EV platforms, and some digital technologies. Rather than trying to catch up across the board, Europe could identify its next wave of advantage, build defensible niches, and move faster in areas where it still can win. In AI, for instance, it could focus on developing specialized models in industry, healthcare, or defense, as well as open-source approaches.
- Secure access, capability transfer, and adoption in scaled technologies—such as leading-edge semiconductors, cloud infrastructure, and cybersecurity—if catching up proves unrealistic or would be too slow. The goal is not full self-sufficiency but reliable access, selective domestic capability, and stronger partnerships.

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[1] *The race takes off in the next big arenas of competition*, McKinsey Global Institute, March 26, 2026.
[2] *Europe in the intelligent age: From ideas to action*, McKinsey and the World Economic Forum, January 17, 2025.

Specialize in less cost-sensitive, more critical industries: future-shaping arenas and critical chokepoints

The structural cost gap in many advanced economies, together with increasing costs of capital and growing demand for investment in the capital-heavy AI value chain, make broad-based reindustrialization difficult to justify on financial grounds alone. In this context, specialization becomes even more important, and two criteria are vital: future competitiveness and geopolitical security.

For the first, industries in the next big arenas such as AI, biotechnology, chips and electric vehicles warrant investment because not doing so may foreclose future options.[80] These industries also tend to be less cost-sensitive—AI data centers brought to market today can command much higher revenues than those that come online after delays. South Korea's bet on memory chips and displays in the 1980s and '90s illustrates this: Underwritten by patient state capital and industrial coordination, the country established competitive positions that are still strong four decades later. Today, many proponents of AI contend that AI computing infrastructure occupies a unique position in this space, as it is a master input capable of reducing costs and restoring manufacturing competitiveness across the board—but even the AI value chain requires large investments into traditional industries.[81]

The second criterion is for specialized investment in industries that offer greater strategic autonomy and protection from supply chain disruption. The COVID-19 pandemic and the wars in Ukraine and the Persian Gulf have highlighted the fragility of supply chains ranging from energy to semiconductors, while restrictions in access to powerful AI models alerted countries to the strategic importance of leading technology capabilities. Of course, the most resilient system is not the most localized one but the most diverse one. Removing a chokehold is not the only response; counterbalancing chokeholds is also an option.

Level the playing field with industrial policy

An additional option for countries seeking to close their investment gap is to explore a tool kit of policy interventions. The use of industrial policy measures has been on a steep rise since 2011, when the Doha Round of trade negotiations among members of the World Trade Organization failed (Exhibit 23).[82]

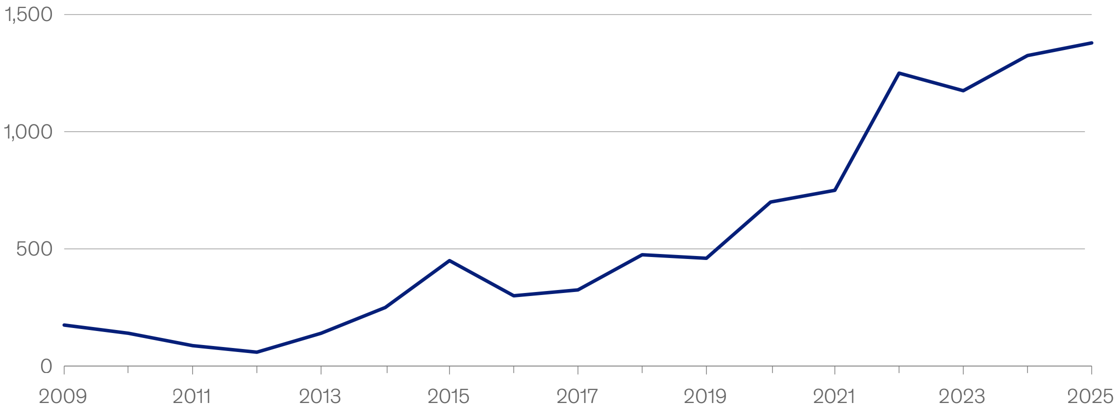
At the same time, the composition of industrial policy has shifted, with national security and geopolitical concerns underpinning more than half of these interventions.[83]

The industrial policy catalogue spans a broad set of interventions that promote favored firms or industries. The main measures are direct and indirect subsidies and incentives that reduce the cost base of domestic or foreign companies investing and operating in a country, as well as trade restrictions such as import tariffs, quotas, and local content requirements that increase costs for foreign producers selling into a domestic market.[84] The policy tool kit also includes measures such as public procurement, price floors and stockpiling to bolster demand, and market regulations and standards that impact the propensity of firms to invest. Export controls, foreign ownership restrictions that protect strategic positions already in place, capital controls and currency interventions that influence relative price levels are other policies counties deploy, as well as, potentially, sanctions and conflict.[85]

Exhibit 23

Industrial policy action has surged since 2012.

Number of industrial policy actions[1]



Note: Adjusted for reporting lag.
[1] Subsidies and state aid, export incentives and export restrictions, import barriers and trade defense, FDI screening and incentives, procurement and localization policies, and other technology-related and behind-the-border measures.
Source: New Industrial Policy Observatory database, Global Trade Alert, December 2025

McKinsey & Company

OECD research indicates that subsidies have almost tripled since before the 2008 global financial crisis and that Chinese firms receive on average three to eight times more support than firms based in advanced economies. Average subsidies received by firms based in Europe amounted to less than 0.5 percent of annual revenue from 2005 to 2024, compared with roughly 1 percent in North America and roughly 2.5 percent in China.[86] These estimates include grants, income tax concessions, and borrowing at below-market rates, but don't capture the full scope of government support. For example, China also offers companies access to land or property free or at low rates, amounting to roughly an additional 0.5 percent of GDP in subsidies.[87]

Industry-level evidence illustrates a similar pattern. Support for semiconductor fabrication has increased across all major regions, but China's subsidies are most generous at 10 percent of revenue on average, despite a more competitive underlying cost structure, as shown in this report. By comparison, semiconductor fabs are subsidized by 2 to 3 percent in the United States and Europe.[88]

Beyond subsidies, the International Monetary Fund estimates that the real effective exchange rate in China was undervalued by 12 to 21 percent in 2025—a finding China has contested.[89] This makes exports cheaper than they would be if valued at market rates and therefore helps domestic producers in a manner similar to subsidies. The downsides of such a strategy are that it can widen external trade imbalances, drive up the prices of imported goods for consumers, and reduce the value of household and business assets on the global market. It can also delay development of stronger domestic demand and intensify trade tensions, as has been the case with China's export-driven development model.[90]

The playing field is not level today, and there is risk of escalating interventions. In a perfect world, countries could mutually rebalance existing market skews, allowing capital to flow to the most competitive and productive locations. In a period of rebalancing, carefully considered interventions could restore a system that ensures sufficient productive capacity, enriches competitiveness, and advances innovation, building resilience and greater stability around the world.

In a fracturing world, competitiveness matters more than ever. Restoring it where it is lacking will require real change from governments and companies on multiple fronts. The prize is substantial: more growth where it has stalled, more resilience where it is missing, fewer imbalances where they have built up, and more broadly shared prosperity.

10 investment cases in detail

These investment cases explore the costs of projects in ten industries critical to economic growth and resilience in different regions. Cost differences around the world help explain why investment is attracted to some regions and not others. The collection should not be read as a comprehensive analysis of the industries covered. The ten industries are grouped in three types.

Investment case

Nuclear power: A renaissance in the making

The explosion of AI data centers and the continued electrification of automobiles and other products have greatly increased demand for electricity, sparking renewed interest in producing nuclear power.

by Benjamin Sauer, Chad Cramer, Anna Kortis, and Olivier Bus

Nuclear power has become sexy again, thanks to expectations of much greater demand for energy, global efforts to reduce carbon emissions, and additional focus on energy security and geopolitical resilience. According to the International Atomic Energy Agency, nuclear power generation could more than double by 2050 as more countries install plants and new models such as small modular reactors (SMRs) and microreactors that can be assembled in a factory come online.[1] Although SMRs are still in the early stages of commercialization, they could reshape construction timelines and costs.

This investment case is one of ten that are the foundation of the McKinsey Global Institute's report, *Catalyzing competitiveness: Where investment happens and why*. The report examines how variations in the basic economics of comparable projects influence investment decisions in different regions globally and the impact those decisions can have on the future of competitiveness and growth across the world.

AI, electrification, and onshoring are propelling demand for nuclear capacity, but scaling will be challenging

The current standard for nuclear power generation is large-scale plants that produce electricity by splitting uranium atoms to create heat, which turns water into steam that propels a large generator. A technology that has operated for decades in many countries, nuclear reactors deliver steady, around-the-clock power with a minimal carbon footprint. This article focuses on so-called Generation III-plus pressurized water reactors to understand what drives cost differences in nuclear power generation across geographies. These reactors typically have a capacity of about 1 gigawatt. Unlike previous generations of nuclear reactors, Generation III-plus reactors incorporate layers of passive safety and more robust containment, aiming to operate for a minimum of 60 years while almost continuously online. These features enable the technology to supply a dependable baseload of energy alongside growing shares of wind and solar power.

More than 400 nuclear reactors with approximately 400 gigawatts of capacity produce roughly a tenth of the world's electricity globally, and at least 60 more reactors are currently under construction.[2] Output has started to rise again after a period of flatlining, as new units in Asia and the Middle East and programs to extend the lives of established reactors in advanced economies and elsewhere, offset reactor retirements elsewhere. Looking ahead, the McKinsey Global Energy Perspective's net-zero scenarios suggest nuclear capacity will at least double and potentially triple by midcentury, meaning up to 1200 gigawatts of nuclear capacity could be available.[3]

Such scale-up implies significant investment in plants themselves as well as in upstream fuel and key components, which depends on whether countries can build units at predictable costs and pace, establish the needed institutional capacity, and secure public support.

One way to ease some of these constraints is to consider a different reactor model altogether. SMRs, which typically produce less than 300 megawatts, could reshape the industry by enabling more standardization, off-site manufacturing, and serial production, potentially trimming construction times and fitting into regional grids or industrial hubs where gigawatt-scale reactors would not fit. More than 90 SMR concepts are currently in development, with the most advanced moving from blueprint to construction now.[4]

Increasing nuclear investment requires scaling up complex, highly concentrated supply chains

The nuclear industry is organized around two tightly coupled supply systems, uranium fuel and plant components. The fuel chain runs from uranium mining through conversion, enrichment, and fuel assembly fabrication, controlled at each step by a small number of companies and state-connected enterprises concentrated in a handful of countries and regions. Enrichment is the most concentrated and capital-intensive link in the chain, and demand for the high-assay low-enriched uranium required by next-generation reactors threatens to outstrip today's limited capacity in Western countries. Rebuilding secure supply is costly: Recent McKinsey analysis estimates the United States alone would need to invest $105 billion to $170 billion across the fuel cycle to meet its 2050 nuclear ambitions.[5] This link exposes the industry to policy shifts and trade restrictions as demand grows.

The component supply chain spans reactor "nuclear island" and "turbine island" systems. A small group of original equipment manufacturers (OEMs) set standards for Tier 1 items such as reactor vessels, steam generators, and coolant pumps. These require extensive forging, specialized alloys, and long lead times, making them susceptible to bottlenecks. Tier 2 components such as valves, sensors, piping, switchgear, concrete, and other subassemblies have more suppliers, often found in the aerospace and thermal power industries, though they must still meet nuclear-grade specifications in most cases.

Ownership and operating models vary by region, but in most programs a regulated utility or state-owned operator ensures integration across development, delivery, and long-term operations. Historically, the "owner engineer" model in which utilities maintained strong in-house engineering and project-delivery capabilities was a major source of execution strength, particularly in the United States as well as in France and Japan. Over time, many utilities reduced internal engineering capacity and largely lost these capabilities. Today, European programs are led mainly by state-backed utilities that rely on government-supported financing; US plants are owned and operated by private utilities, backed by federal financing support and overseen by a federal safety regulator, and Chinese projects are vertically integrated state-owned enterprises that span fuel, equipment, construction, and operations.

Regulators, export-credit agencies, and energy ministries provide licensing, safety oversight, and, in some cases, participate directly in financing. In multi-unit programs, the same ownership and operating teams often serve many sites, drawing supply chains into longer-term partnerships with OEMs and engineering, procurement, and construction integrators.

Demand ultimately underwrites this supply chain. Grid electricity buyers anchor demand, with utilities in China, Europe, and the United States buying stable, low-carbon power under a mix of regulated tariffs, power-purchase agreements, and market participation. Beyond the grid, new customers are emerging as Generation IV reactors that have higher output steam temperatures come online. Industries are exploring direct use of nuclear heat and steam for process applications, and some markets are evaluating district heating and desalination links. Additionally, large technology companies are investing in dedicated nuclear power for data centers and digital infrastructure.

Half of recent new reactors are in China, which could overtake the United States as the largest generator of nuclear power by 2035

France and the United States are home to the largest existing nuclear fleets, together accounting for 40 percent of global installed capacity made up primarily of Generation II reactors. Many of those reactors were built in the 1970s and 1980s, when France embarked on one of the world's most successful serial nuclear building programs, standardizing designs and driving costs down through replication.

China is now deploying standard Gen III+ units and accounts for half of recent grid connections.[6] It will soon surpass France and likely overtake the United States as the world's largest producer of nuclear energy by 2035.[7] South Korea offers another example of how standardization can support delivery: The world's fifth-largest nuclear electricity producer has paired standardized reactor design with disciplined project management, both at home and as an exporter. Countries that haven't traditionally had nuclear power are investing at scale. The United Arab Emirates, for example, has commissioned multiple units at a single site, and India has set an ambitious target of 100 gigawatts of nuclear capacity by 2047, incorporating private-sector participation and financing for the first time.[8] These newer examples of nuclear implementation illustrate that standardized designs, repeatable work, and mature supply chains can lower costs and shorten ramp-up periods.

South Korea has among the lowest costs globally, thanks to design standardization, supplier continuity, and scale

Three practices explain South Korea's competitiveness. First, projects select a design early and replicate it from unit to unit, reducing costly changes late in construction and making fieldwork more predictable. Second, each project is led by a capable engineering and construction integrator with continuity across major suppliers and site teams, ensuring that learning carries over between units. Third, South Korea has established a strong nuclear supply chain that can produce core nuclear plant components domestically. The size of its program enables not only local capability but also economies of scale. Nuclear plant programs that have deployed these practices, whether in South Korea or at the Barakah site in the United Arab Emirates (built by a Korean-led consortium using South Korea's APR1400 design) have had lower costs and shorter schedules, consistently achieving full-scale operation in less than a decade.

These achievements, combined with stable financing and strong operating performance, have enabled South Korean projects to achieve competitive "overnight" construction costs, the engineering term for the price to build a plant if it could be completed overnight. This is key because the levelized costs of a nuclear plant are dominated by capital outlays rather than ongoing operating expenses.[9] Labor, maintenance, and fuel together account for about 40 percent of a nuclear plant's levelized costs, with capital costs making up the rest (see sidebar, "Methodology").

Sidebar

Methodology

This investment case compares the costs of a greenfield nuclear project across various geographies to understand what makes some regions more cost-competitive than others. Our levelized cost methodology converts a project's full life cycle economics into a single unit cost. It can be interpreted as the unit price that would make a project's net present value equal to zero over its entire life cycle, which is the minimum price that makes that project viable and is in line with the macroeconomic concept of long run marginal costs. It is also in line with the macroeconomic concept of long-term marginal costs. The levelized cost concept is commonly applied in the energy sector, where it is known as the levelized cost of energy. We do not consider taxes, subsidies, and externalities, which vary and are hard to pin down.

The calculations are informed by McKinsey's work in the nuclear industry, which provides our understanding of the capital expenditure, labor, energy, materials, and other inputs, as well as time, typically needed to build and operate a nuclear plant. We price the inputs at the typical costs in a geography, drawing on proprietary databases maintained by MGI's Economics Research team, and at the typical weighted average costs of capital, drawing on McKinsey's Value Intelligence platform, a curated database of the financials of companies globally.

Construction costs account for the largest share of levelized cost differences between countries and this cost is composed of direct construction costs and the cost related to capital expenditure inefficiency. We combine these categories because direct costs and inefficiency are closely intertwined: Longer construction times, design changes during construction, and greater project complexity drive both, compounded by higher construction costs for materials and labor regardless of schedule. Compared to the South Korea benchmark, total construction costs add $50 to $60 per megawatt-hour to projects in France and the United States, while in China, these costs are approximately $3 less due to lower materials and labor costs.

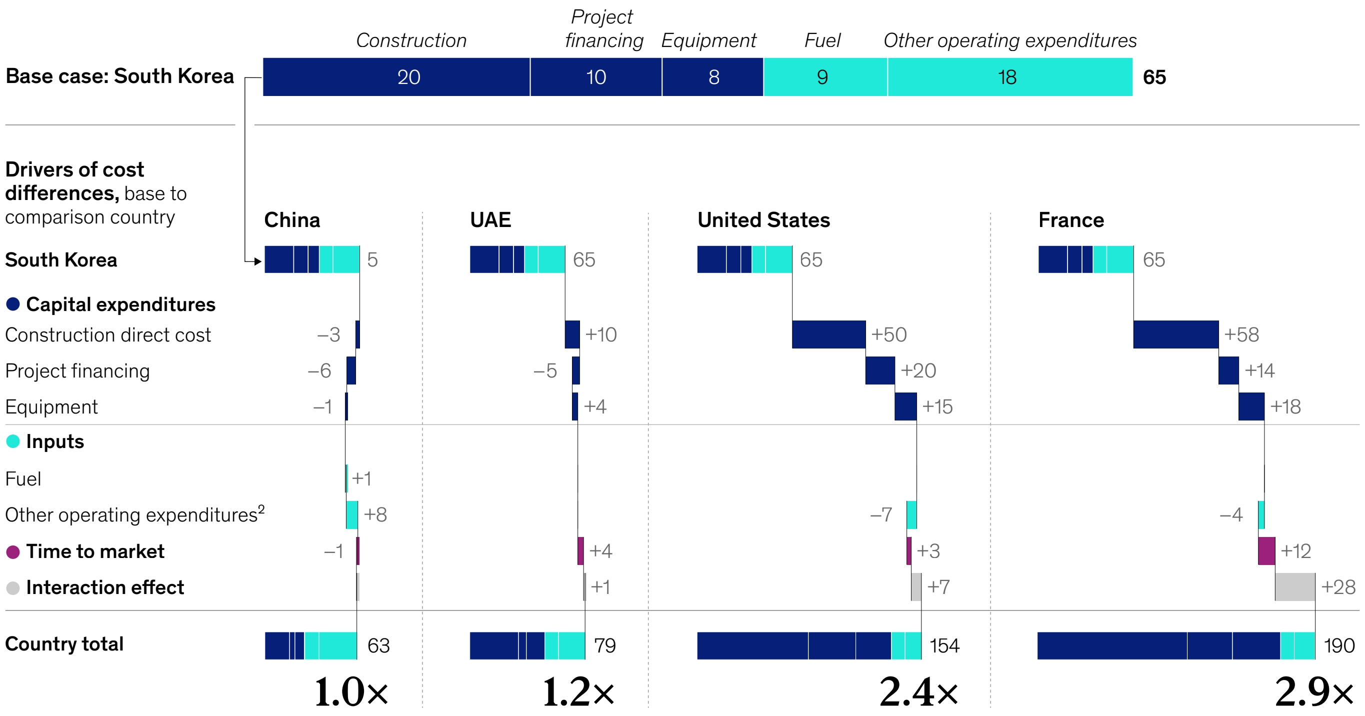
Direct costs of construction reflect the underlying costs of civil works and buildings, such as materials like concrete and metals, utilities and equipment, rental of equipment like cranes and bulldozers, and construction wages, including specialized labor. Compared to South Korea, US construction labor costs adjusted for productivity are about 80 percent higher, and US concrete prices are roughly 200 to 250 percent higher.

China's levelized costs are on par with South Korea's, reflecting a highly standardized, repeatable nuclear build program. Projects follow a consistent script, with some recent reactors moving from first concrete to grid connection in as little as six years.[10] A single reactor design family has accounted for more than a third of units completed since 2000, and its successors, together with another model, now make up nearly nine in ten reactors under construction in China and many of those newly approved.[11]

Exhibit 1

Capital expenditure costs drive the economics of nuclear power plants.

Levelized cost of energy,[1] $/megawatt-hour, before taxes and direct subsidies



Note: Figures may not sum, because of rounding.
[1]We consider a 1000 MWh generation III+ nuclear fission reactor for this comparison.
[2]Includes direct and indirect labor costs and maintenance costs.
Source: International Energy Agency; Institute for Energy Economics and Financial Analysis; Cour des Comptes; McKinsey Global Institute analysis

McKinsey & Company

Capital expenditure inefficiency as a result of longer construction times and bespoke designs adds substantial costs in Europe and the United States. The Hinkley Point C project in the United Kingdom, where construction will take more than a decade, illustrates the pattern. Environmental mitigation requirements alone added £700 million to the project.[12] By comparison, Chinese, Emirati, and South Korean nuclear fleets have held overnight construction costs to competitive levels with replicable scope, stable policy environments, and disciplined execution. For instance, the Emirates has deployed a proven Korean design and associated requirements and regulations. That project also illustrates how programs that set design early, build multiple identical units on a single site, and keep the same Tier 1 suppliers from unit to unit reduce construction hours and rework. As teams repeated identical scopes, indirect services and owner's costs fell sharply at the Barakah plant, helping reduce costs from construction of the first unit to the fourth by roughly 40 percent.

Equipment pricing and sourcing of nuclear-grade items with long lead times such as reactor vessels and components, steam generators, reactor coolant pumps, and turbine islands account for a smaller cost difference of $14 to $20 per megawatt hour in the United States and France. These differences reflect a concentration of Tier 1 suppliers, limited global metal forging capacity, and bespoke specifications that constrain vendor competition. Programs with qualified domestic suppliers or long-horizon agreements can reduce these premiums.

Project financing reflects the cost of capital during a long build. Relative to the benchmark, financing effects add roughly $15 to $20 per megawatt hour in France and the United States. Both countries already deploy concessional financing: France is providing subsidized loans at preferential rates for its European pressurized reactor 2 program and the United States extended $12 billion in federal loan guarantees for the Vogtle plant expansion in Georgia. Without such support, financing costs would be even higher. The premium persists because longer construction timelines keep capital at risk for longer, amplifying interest costs even when financing terms are favorable.[13]

Time to market reflects the time value of money beyond the cost of time spent on construction and implementation. South Korea has construction times of six to eight years, compared to close to two decades for recent projects in Europe and the United States. Only China builds nuclear plants faster, recently completing a unit in 70 months.[14]

As noted, construction timelines have a significant impact on the overall cost of building reactors. The “pure” time component, however, represents only about 10 percent of the total difference in cost for France versus the South Korean base case because even though construction in France takes significantly more time, the overall useful life of the reactor as modeled in this investment case comparison is the same at 60 years from start of construction. Countries where median build time is about eight years cluster near the South Korean base case. Time to market adds about $12 per megawatt-hour to the price of nuclear power in France and $3 in the United States, compared with $4 in the United Arab Emirates. In China, it reduces costs by about $1. The causes of these differences are related to the same execution disciplines noted above.

All remaining items such as materials, labor, and other operating costs contribute very little to cost differences between countries.

Nuclear construction is concentrated in Asia; new tactics can close the cost gap in other regions

Momentum for nuclear power is generally stronger in Asia than in Western economies. South Korea continues to add nuclear capacity per capita at a high rate, with four gigawatts under construction for its population of 50 million. China accounts for more than half of new nuclear power coming online, adding 44 gigawatts to the 60 gigawatts it already has. In addition, China plans to build another 48 gigawatts of capacity and has proposals for 172 gigawatts more. Russia has four gigawatts under construction and 22 gigawatts planned, while India has seven gigawatts underway, plans for an additional eight gigawatts, and a goal of 100 gigawatts by 2047.[15]

By comparison, the United States has no large new reactors currently under construction, although Westinghouse has announced plans to begin construction by 2030 of a fleet of ten AP1000 units that could produce roughly 10 to 11 gigawatts.[16] Europe has slightly bigger aims for nuclear power production, with about 5.5 gigawatts under construction, close to 30 gigawatts planned, and another 20 to 30 gigawatts proposed.[17]

Public perception and government policies are decisive in where nuclear projects proceed

Factors beyond cost also determine where projects go. Some countries, particularly those without abundant domestic fossil-fuel resources, such as France and Japan, value nuclear power's contribution to energy security and resilience, and the US–Iran conflict in 2026 may strengthen the case for nuclear power further. The levelized cost of a nuclear plant is locked in after construction, and operating costs, which are more insulated from price shocks than gas-generated power, are relatively low. However, concerns around perceived nuclear safety and previous decommissioning decisions still impede the nuclear build-out in Germany and other countries.

Companies and policymakers can take steps to make sure projects are economical, which will ensure nuclear power is part of the energy portfolio in countries that need it.

First, companies can build fleets of plants to reduce cost and time to market. Repeating standardized designs across multiple projects, as China and South Korea do, reduces costs and compresses schedules. Modular construction, integrated project delivery, and aligned incentives across owners and contractors reduce change orders, decrease labor hours, and make execution more predictable.

Second, policymakers could complete licensing before construction begins and take steps to ensure that policy support doesn't shift in the middle of construction, which creates delays and raises costs. Better coordination across policymaking entities and stakeholders is also critical, as noted by the UK's 2025 Nuclear Regulatory Review, which found that a single project can face as many as eight regulators with no designated lead.[18] Public financing sized for multi-unit programs could bolster confidence in developers and suppliers.

Finally, reducing operational and market risks and reducing financing costs could improve the investment case for nuclear projects, which are increasingly attracting private investment.[19] Sovereign support, export-credit financing, loan guarantees, indexed power purchase agreements, and contracts for difference can reduce financing costs. These tools matter most for first-in-country or first-of-a-kind projects that have high execution risk.

The nuclear potential is real around the world. Translating it into nuclear projects requires the discipline to build competitive fleets that attract investment and warrant public approval.

Benjamin Sauer is a McKinsey partner based in the Frankfurt office, **Chad Cramer** is a McKinsey partner based in the Columbus, Ohio, office, **Anna Kortis** is a McKinsey partner based in the Vienna office, and **Olivier Bus** is a consultant based in the Amsterdam office.

Investment case

Solar power: From intermittent sunshine to reliable power

Solar photovoltaic projects with battery energy storage systems are moving beyond low-cost generation by transforming intermittent output into more reliable, higher-value electricity.

by Andreas Schlosser, Nas Andriopoulos, Anna Kortis, and Olivier Bus

Global solar demand is growing dramatically, a reflection of growing energy use around the world, rapidly decreasing costs of solar photovoltaic and battery storage technology, and the drive to replace fossil fuels with renewable energy sources in many places. Today, China is by far the largest investor in solar photovoltaic (PV) generation and the largest producer of solar panels. But in contrast to many other markets, solar truly is a global growth industry, now representing over 40 percent of the investment in global power generation.[20]

This investment case is one of ten used in the research for the McKinsey Global Institute's report, *Catalyzing competitiveness: Where businesses investment happens and why*. The report examines how variations in the basic economics of comparable projects influence investment decisions in different regions globally and the impact those decisions can have on the future of competitiveness and growth across the world.

Solar energy is one of the fastest-growing energy investments globally

Solar PV systems, which convert sunlight into electricity, typically fall into three segments: utility scale, commercial and industrial, and residential installations.[21] Utility-scale systems are ground-mounted installations, often called solar farms, with a capacity of at least one megawatt. They account for about two-thirds of installed solar PV volume in 2024 and are the primary focus of this analysis.[22]

Investment in solar PV in all segments reached about $400 billion in 2025 and is expected to decrease slightly to $365 billion in 2026, which is roughly 55 percent of total renewables investment. It is the single largest category of investment in power generation, ahead of wind, hydro, gas, nuclear, and coal.[23] Investment in battery energy storage systems (BESS) is also rising rapidly and reached about $80 billion in 2025. Solar generates power only when the sun is shining, while BESS stores electricity to discharge when demand and prices are higher. Projections suggest investment in storage will exceed more than $100 billion in 2026, reflecting the growth of solar PV.[24]

In practice, BESS is deployed as a standalone asset and in combination with solar PV. This pairing has become more important as solar deployment has scaled. Solar PV has very low operating costs because, unlike conventional coal- or gas-fired power generation, it does not require fuel inputs. However, it does require significant upfront capital investment in modules, inverters, and balance of system hardware. Those equipment costs have declined rapidly over time. Solar panel prices are down by about 98 percent since the 1990s, driven by manufacturing scale, technological improvements, and supply chain efficiencies.[25] A highly industrialized supply chain led by Chinese manufacturers, which supply more than 80 percent of global solar modules and many other components, underpins this cost decline.[26]

China also leads the supply chain for battery cell manufacturing, supplying more than 75 percent of global production.[27] Battery costs have also fallen sharply, declining by about 75 percent over the past decade.[28] Solar economics are no longer shaped by generation costs alone but increasingly by the ability to store electricity and deliver it when demand and prices are highest. That is accelerating the adoption of hybrid solar PV + BESS projects in many markets.

Solar deployment is global, although China remains far ahead. However, as solar penetration increases, the economics of solar PV are no longer determined solely by generation costs. The inherently intermittent nature of solar output means that the ability to deliver electricity when it is needed is becoming increasingly important.

China installs more solar than the rest of the world combined

Solar deployment has accelerated globally as project costs have dropped. Over the past decade, the cost of adding one gigawatt of solar PV has fallen by roughly 80 percent, spurring an almost tenfold rise in annual capacity additions.[29] Deployment is now widespread in major regions, although the scale and configuration of projects vary significantly by geography (table).

In markets with abundant land and strong solar irradiation—notably China's western regions, India, the Middle East, Australia, Brazil, and large parts of the United States—developers often build very large utility-scale projects. In more land-constrained markets, especially in Europe, projects tend to be smaller and more distributed. Because solar PV is highly modular, costs generally rise roughly in proportion to project size. In utility-scale solar, doubling project size typically reduces capital costs per watt by about 7 percent, mainly through shared infrastructure.[30]

Table

Installed utility-scale solar PV capacity and recent additions by country

Country	Installed capacity (gigawatt, 2024)	Capacity additions (gigawatt, 2025)	Region considered for investment case in this report[1]
China	358	88	Inner Mongolia
United States	128	35	Texas
India	78	32	Rajasthan
Spain	31	8	Extremadura
Rest of EU-27	88	30	-
Brazil	15	6	Minas Gerais

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[1] These regions are the locations with solar capacity that were part of this research.

China is far ahead in utility-scale solar power generation. With about 360 gigawatts installed in 2024 and almost 90 gigawatts added in 2025, its scale reflects a combination of low equipment costs, rapid build-out, and large desert-based projects in Inner Mongolia. Outside China, the main markets are in Brazil, the EU-27, India, and the United States. Sunny Spain is one of the EU-27's main large-scale solar hubs, producing about 40 gigawatts in 2025 supported by strong irradiation and available land.[31]

Despite similar irradiation levels, US costs are almost twice China's

Our base investment case models firm solar power as a direct current-coupled hybrid solar PV and BESS, a 250-megawatt solar installation paired with a battery to secure 95 percent reliability levels.[32] In a direct current-coupled design, the battery is connected on the direct current side of the solar array, allowing it to charge directly from solar output before conversion to alternating current.[33] Inner Mongolia is used as the base case given its scale and cost advantages (see sidebar "Methodology").

The levelized cost of firm solar power measures the average cost of delivering a megawatt hour of electricity from a solar PV project paired with battery storage over a project's lifetime. Our analysis finds levelized cost ranges from about $50 per megawatt hour (MWh) in China to $110 per MWh in the United States. Costs in Brazil and India are $65 per MWh, while costs in Spain are $95 per MWh (Exhibit 1).[34] In all these markets, capital expenditures are the primary component of levelized cost, and equipment is the single largest contributor.

Adding BESS raises levelized cost relative to standalone solar PV by about $30 to $70 per MWh, reflecting the added cost of the battery system to deliver power more reliably. This wide range in costs is largely driven by transportation and logistics costs and tariffs because China is the main supplier of BESS.[35]

Sidebar

Methodology

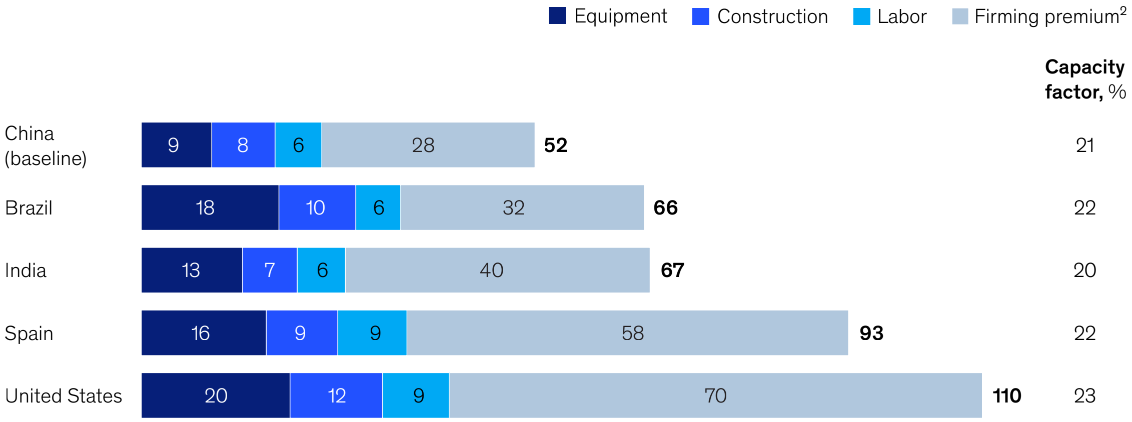
This investment case compares the costs of a solar photovoltaic project with battery energy storage across various geographies to understand what makes some regions more cost competitive than others. Our levelized cost methodology converts a project's full life cycle economics into a single unit cost. It can be interpreted as the unit price that would make a project's net present value equal to zero over its entire life cycle, which is the minimum price that makes that project viable and is in line with the macroeconomic concept of long run marginal costs. The levelized cost concept is commonly applied in the energy sector, where it is known as the levelized cost of energy. We do not consider taxes, subsidies, and externalities, which vary and are hard to pin down.

The calculations are informed by McKinsey's work in power and renewables, which provides our understanding of the capital expenditure, equipment, installation, operations and maintenance, storage, and timing typically needed to build and operate a solar PV project paired with battery energy storage. We price the inputs at the typical costs in a geography, drawing on proprietary databases maintained by MGI's Economics Research team, and at the typical weighted average costs of capital, drawing on McKinsey's Value Intelligence platform, a curated database of the financials of companies globally.

Exhibit 1

The so-called firming premium is the largest driver of cost differences across the industry.

Levelized cost of energy for utility-scale solar PV plus battery energy storage systems, $/MWh,[1] before taxes and direct subsidies



Note: Levelized costs are pretax. Based on 24/7 renewable economics for firm solar and wind; firming premium calibrated to 95% reliability.
[1] Numbers may not sum precisely, due to rounding.
[2] A "firming premium" is the extra cost of converting variable solar output into round-the-clock power, covering the additional battery storage and overbuilt solar capacity required to meet a set reliability level, in this investment case 95%.
Source: International Renewable Energy Agency; McKinsey Global Institute analysis

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Tariffs on equipment drive costs in the United States, while financing raises costs in emerging economies

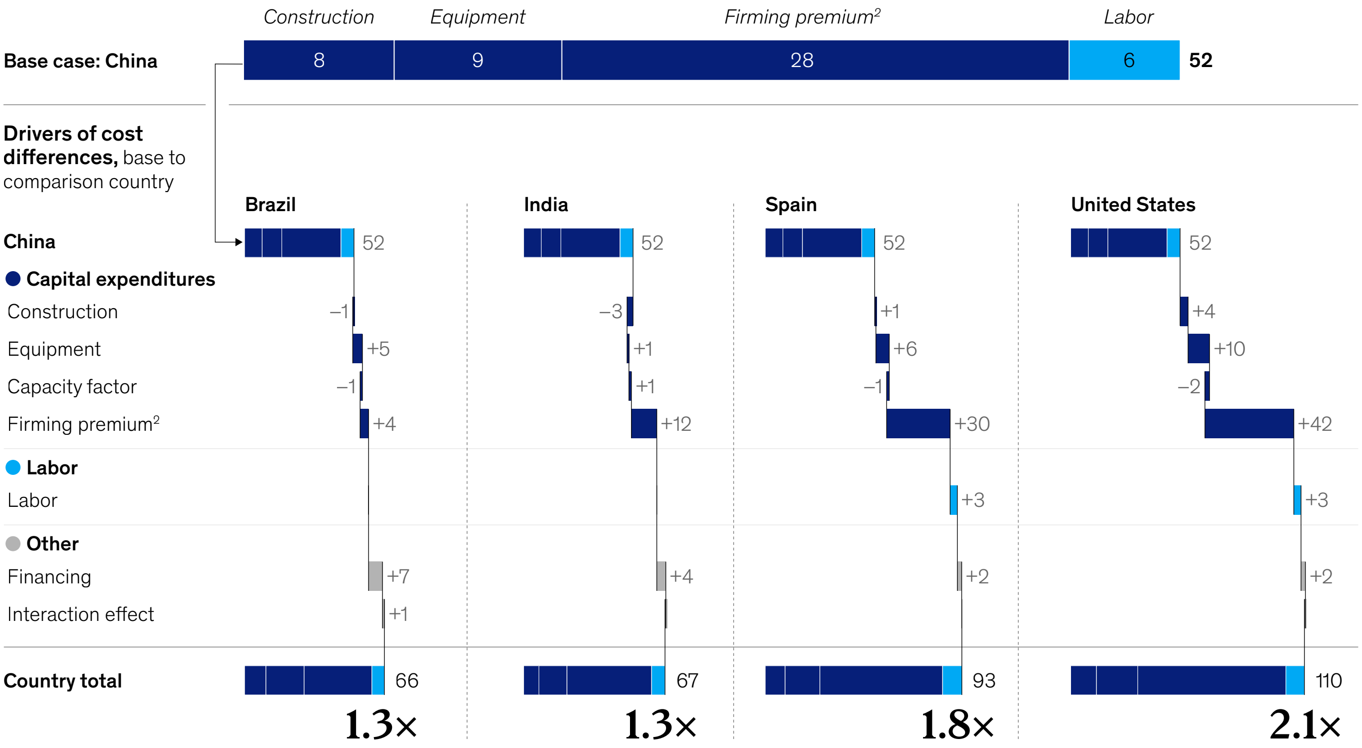
Most of the variation across countries is driven by the additional cost of battery storage and shifting output to deliver continuous, reliable power, known in the industry as a "firming premium" (Exhibit 2). This adds $30 to $42 per MWh to costs in Spain and the United States respectively and explains roughly three-quarters of the cost gap compared to China. Because this premium is almost entirely upfront capital for batteries and extra solar capacity, it largely reflects China's structurally lower battery costs and cheaper financing.

After the firming premium, solar PV equipment is the largest source of variation in levelized cost, adding up to $10 per MWh. Differences in equipment costs reflect a mix of tariffs and trade policy, supplier mix, and domestic manufacturing premiums.

Exhibit 2

Firming premiums account for most of the difference in the costs of a solar PV plus battery energy storage systems facility.

Levelized cost of energy, utility-scale solar PV plus battery energy storage systems,[1] $/MWh, before taxes and direct subsidies



Note: Numbers may not sum precisely , because of rounding.

[1] This analysis is based on a 250-megawatt-direct-current solar PV facility with a firming premium that provides 95 percent reliability.

[2] A "firming premium" is the extra cost of converting variable solar output into round-the-clock power, covering the additional battery storage and overbuilt solar capacity required to meet a set reliability level, in this investment case 95%.

Source: International Renewable Energy Agency; Energy Storage Insights; McKinsey Global Institute analysis

McKinsey & Company

Financing or cost of capital is another source of variation, adding $7 per MWh in Brazil and India. In many emerging markets, solar can be built cheaply and quickly, but capital is expensive because investors face concerns about currency stability, contract enforcement, and whether offtakers will reliably pay. The issue is often not solar economics itself, but the ability to attract financing. This is particularly pronounced in African countries, which have the biggest unmet need in developing solar projects.

Access to financing can be improved through support from development finance institutions or political-risk assurances such as the guarantees provided by the World Bank's Multilateral Investment Guarantee Agency, which help lower financing risk and attract lower cost of capital.[36] The weighted average costs of capital used in this analysis are market-level estimates meant to reflect such broad differences in financing conditions rather than the terms available to any specific project.[37]

Storage is critical to maximizing solar revenues

Utility-scale solar projects typically sell electricity through a combination of different revenue mechanisms. Revenues may come from regulated tariffs, contracts for difference, corporate or utility power purchase agreements (PPAs), or direct sales into wholesale power markets where the price is set by other forms of power generation.

The mechanism matters because utility-scale solar power is now among the cheapest forms of electricity in most markets. However, low costs do not guarantee high returns, because solar output is concentrated in the same daylight hours. As more solar power enters the grid at the same time of day, wholesale prices fall or even turn negative during sunny hours.

As more output is sold directly in wholesale markets rather than under fixed-price contracts, solar companies increasingly need ways to improve returns. This is why batteries matter. When paired with solar, BESS can store electricity during lower-priced hours and discharge it later, when prices are typically stronger, creating a potential price increase of $10 to $20 per MWh. Hybridization also increases revenue premiums through tailor-made PPAs based on how closely an asset can match supply and demand of electricity. At one end, an “as produced” solar power plant simply sells electricity when it is generated. On the other end, an “as consumed” plant aims to match the supply and demand much more closely hour by hour and can earn a revenue premium of up to 100 percent.

Batteries also stretch how solar projects earn revenues. BESS revenues typically come from a mix of energy trading. Batteries can supply electricity when prices are higher, help stabilize the grid, and earn capacity payments for providing power when it’s needed. Operators typically optimize across all three to maximize revenues. For example, in the United Kingdom, ancillary services were once the main revenue source for batteries, but energy trading has become much more important as storage deployment has increased and markets have evolved.

Adding BESS to a solar power system also provides a better balance of risk and return. Hybrid projects combining batteries with renewable energy offer a better risk-return profile than single-asset projects, improving the internal rate of return by 1 to 2 percent in mature European markets. AI-enabled dispatch and bidding strategies can lift battery profits by more than 20 percent by helping operators make real-time decisions on when to charge, discharge, and sell into power markets.[38] For hybrid solar-plus-storage projects, the implication is clear: As solar penetration rises, performance will depend less on simply owning a low-cost asset and more on shaping output, managing volatility, and selling power in the most valuable form.

Utility-scale solar plants are typically built, owned, and operated by utilities, developers, or independent power producers, which sell electricity to other utilities or large corporate buyers. In practice, a combination of mechanisms is used to structure revenues. Governments in some markets provide support through mechanisms such as contracts for difference, which provide price certainty. Increasingly, however, projects rely on long-term power PPAs, which improve revenue visibility and reduce investment risk. Solar PV plants may also sell electricity to local utilities in regulated markets or directly into wholesale power markets, where prices are set by other forms of power generation.

Whether a solar project is lucrative or not depends not on the levelized cost but on the cost of solar generation compared to other forms of electricity and on market design and subsidy mechanisms.

As solar scales, the key constraint shifts from cost to integration, monetization, and policy

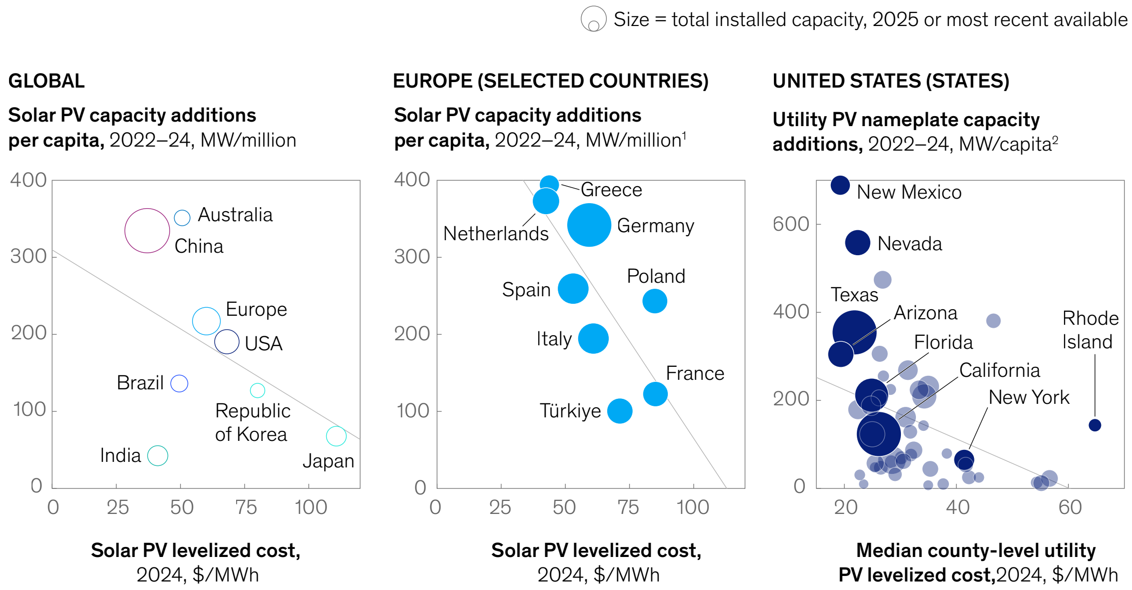
Levelized costs for solar and BESS are falling rapidly. Since 2022, utility-scale battery installation costs have dropped by well over half, thanks largely to technological and manufacturing improvements by Chinese producers including a shift to lower-cost lithium iron phosphate chemistry.[39] Looking ahead, costs are projected to fall by about 50 percent over the next decade, making solar combined with BESS even more attractive. However, these declining costs may not fully pass into every market because of tariffs and other trade barriers.[40]

Cost competitiveness clearly matters because lower-cost solar markets generally correlate with more capacity additions (Exhibit 3). That pattern holds not only across countries globally, but also within regions like Europe and the US states.

Exhibit 3

The pace of rolling out a solar PV facility influences its levelized cost, although other factors also play a role.

Solar PV rollout pace versus levelized cost of energy



[1] Median 2024 for Europe, selected countries.

[2] State data on the average levelized cost of energy (LCOE) differ substantially from the average levelized cost of energy in cross-country data.

Source: International Renewable Energy Agency; US National Renewable Energy Laboratory; McKinsey Global Institute analysis

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But cost does not fully explain where investment flows. The gap reflects factors such as land availability, permitting speed, and grid connection timelines. This is especially important for hybrid solar PV projects that incorporate BESS. Hybrid projects work only if developers can connect to a grid and earn enough value from shifting output into higher-priced hours. Thus, the binding constraint is increasingly not the cost of generating solar power but the ability to integrate BESS and monetize it effectively.

Grid access, revenue levers, and policy design determine investment attractiveness

Grid access is becoming one of the most important constraints in solar power. Even when solar and storage costs are attractive, limited transmission capacity, grid congestion, and slow interconnection processes can delay projects. In the United States, for example, median wait times to connect new solar PV projects are about 60 months.[41]

For investors, opportunity is shifting from building the lowest-cost generation asset to developing projects that can deliver power at higher prices. The most attractive markets are those with fast and reliable grid connection, clear ways to monetize storage, supportive incentives, and bankable revenue mechanisms such as PPAs or contracts for difference. In these markets, solar PV + BESS can earn more by shaping output, reducing price exposure, and matching customer demand more closely.

For policymakers, the priority is also changing. As equipment costs continue to fall, the challenge is less about subsidizing solar generation and more about enabling deployment at scale while keeping system costs down. That means accelerating permitting and interconnection, expanding transmission infrastructure, creating market mechanisms that reward flexibility and storage, and managing supply-chain risk.

China's dominance in PV and BESS equipment has lowered costs globally but also raises concerns about resilience and dependence on external suppliers. As solar PV becomes cheaper, the countries benefiting from it the most will be those that can connect it quickly, store and distribute it effectively, increase system flexibility to match its intermittent profile, and thus turn intermittent sunshine into reliable, higher-value power.

Andreas Schlosser is a McKinsey partner based in the Munich office, **Anna Kortis** is a McKinsey partner based in the Vienna office, **Olivier Bus** is a consultant based in the Amsterdam office, and **Nas Andriopoulos** is a consultant based in London.

The authors of the McKinsey Global Institute report, *Catalyzing competitiveness: Where investment happens and why*, would also like to thank Colin Charlton, Patrick Chen, and Predrag Ignjacevic for contributing to this research.

Investment case

EAF steel: Beyond the blast furnace

Global steel investment is flat, but DRI-EAF production is gaining share in advanced economies

by Karel Eloot, Jeffrey Lorch, Dirk Durinck, Anna Kortis, and Olivier Bus

Steel is the backbone of the global economy. It is the skeleton of most of our infrastructure, buildings and factories, and a critical component of many products households rely on, from cars to dishwashers and bedframes. In industrialized countries, in-use stocks of steel range from 11 tons and 16 tons per capita.[42]

The global steel market is a game of costs, shaped by energy prices and persistent overcapacity. In 2024, the industry had capacity to produce more than 2.5 billion tons when demand was only about 1.9 billion tons.[43] Much of this excess capacity is in China, which ramped up steel manufacturing to support its rapid urbanization and industrialization, compressing margins for steel producers globally. However, geopolitics, sustainability considerations, and advances in technology are changing the rules of the game. This is leading to a more fragmented industry increasingly determined by regional policies and resource constraints that are shifting the terms of global cost competition in the industry.

This investment case is one of ten that are the foundation of the McKinsey Global Institute's report, *Catalyzing competitivess: Where investment happens and why*. The report examines how investment propels competitiveness, and vice versa by analyzing the variation in costs across industries in regions around the world.

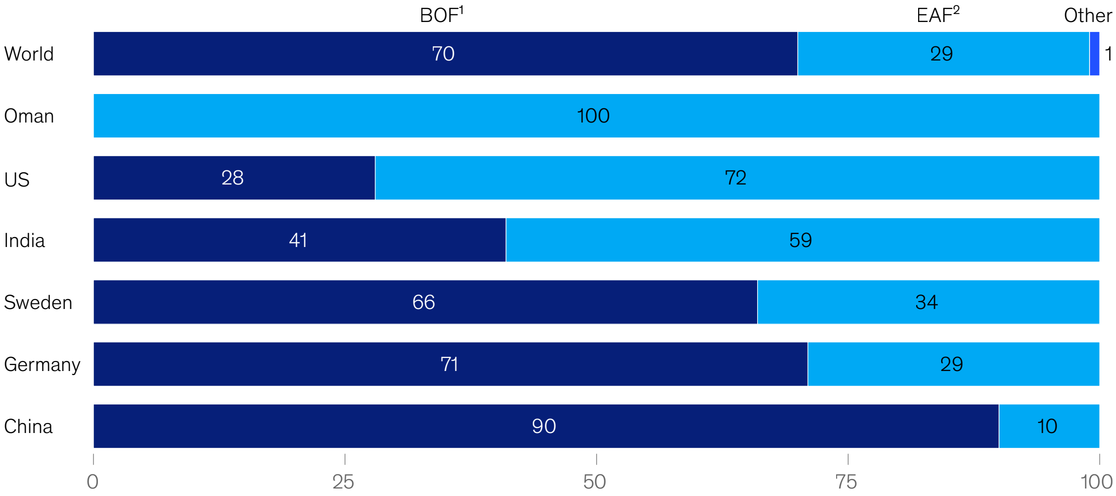
Different production processes predominate in China, the Middle East, and the United States

Globally, approximately 70 percent of crude steel is produced with blast furnace–basic oxygen furnace (BF-BOF) technology, which uses iron ore and metallurgical coal as inputs. Electric arc furnaces (EAF) can remelt prime scrap, a process potentially combined with direct reduced iron (DRI) (see Sidebar: Steelmaking technologies). However, the production mix differs significantly by region (Exhibit 1).

Exhibit 1

Electric arc furnace steel manufacturing is still an emerging technology.

Split per technology in 2024, %



[1] Blast oxygen furnace steel manufacturing.
[2] Electric arc furnace steel manufacturing
Source: *World steel in figures 2025*; McKinsey Global Institute analysis

McKinsey & Company

The United States produces approximately 70 percent of its steel with EAF, partly using its abundant scrap resources. The Middle East is also a big user of EAF. For example, Oman's steel industry operates entirely on EAF production, taking advantage of the country's abundant natural gas resources. In European countries such as Germany and Sweden, BF-BOF technology still accounts for most production today, but EAF is gaining traction for environmental reasons. New European steel investments, such as Salzgitter's Salcos facility in Germany, are going into DRI-EAF-based plants, which have a smaller carbon footprint, and BF-BOF capacity is gradually being phased out.

By contrast, BF-BOF facilities account for 90 percent of Chinese steel production. EAF technology mostly powered by coal produces 60 percent of India's current output, although the country is shifting to BF-BOF production (see sidebar "Steelmaking technologies").

Sidebar

Steelmaking technologies

There are two types of steel products, flat steel and long steel. Flat steel, such as sheets, coils, and plates, is used when surface quality and tight chemistry control matter, such as in producing cars. Long steel, such as rebar, wire rod, and beams, is used in construction and infrastructure, where strength matters more than surface finish. This investment case focuses on flat steel.

Flat steel can be measured at different stages of production. Crude steel is the material before rolling and finishing. Semifinished slab is the first solid shape after casting, an intermediate used as feedstock for rolling. Hot-rolled-coil is a finished flat product and is the core commodity product, used in construction, pipes and tubing, machinery, and service centers. Hot-rolled coil is the center of the value chain because it is the standard industrial base material from which many downstream products are made and against which flat-steel competitiveness is often assessed.

Hot-rolled coil can be made in several ways. Blast furnace–basic oxygen furnace (BF–BOF) is the most established route. Iron ore is reduced using metallurgical coal (coke) in a blast furnace and refined in an oxygen converter, or basic oxygen furnace. This production method has the lowest cost where coal is cheap but also the highest CO_2 emissions.

Scrap electric arc furnace production melts recycled steel, emitting less CO_2, but residual elements limit its use for flat products without dilution from virgin iron. Direct reduced iron–electric arc furnace, or DRI–EAF technology, uses natural gas and electricity instead of coal to produce steel. The technology, which is the focus of this investment case, significantly reduces CO_2 emissions and so is gaining importance as carbon pricing increases. Our analysis focuses on producing hot-rolled coil steel, the standard product for most downstream flat steel uses, using DRI-EAF processes.

DRI-EAF combines direct reduction, electric melting, ladle furnace, casting, and hot strip mill production. Iron ore pellets are first converted into direct reduced iron, which gives the technology its name, using natural gas or hydrogen. The direct reduced iron is then melted together with a smaller share of scrap, before being cast into slab and rolled into coil. In the production configuration analyzed here, producers rely mainly on virgin iron units from captive direct reduced iron, which gives them tighter control over steel chemistry than using only scrap. Hot-rolled coil requires much more stringent controls on residuals, metallic quality, and consistency than long steel, for which DRI-EAF technology is particularly well suited.

Scrap quality varies, and DRI-EAF production typically relies on prime scrap. Prime scrap, such as offcuts and stamping returns generated during manufacturing, is low in residuals and suitable for high-quality flat steel. Obsolete scrap from end-of-life products such as vehicles and buildings contains higher levels of copper and other residuals that accumulate through recycling and limit its deployment in more demanding steel uses, such as for consumer appliances.

Compared with BF-BOF production, DRI-EAF production is more modular, less emissions-intensive, and typically faster to build. Its economics depends more heavily on the cost and availability of natural gas than on mining scale. Thus, although 60 to 70 percent of hot-rolled coil is still produced globally using BF-BOF technology, DRI-EAF is strategically important because it is one of the few scalable pathways to materially lower emissions and the chosen benchmarked technology.

The business case for DRI-EAF depends on natural gas prices and policy incentives

Investments in steel technologies are made based on the optimal production route in a location. Regions with low natural gas costs or strong policy support attract investment in DRI-EAF technology, and investment goes into BF-BOF technology in areas that are rich in coal and have strong growing domestic demand.

The investment case for DRI-EAF production depends on three factors. First, access to competitive low-cost natural gas for DRI and low-cost electricity to power the EAF is needed.

Second, access to key metallic inputs, especially DRI-grade iron ore and scrap must be secure. Third, supportive policy and trade conditions can lower the investment hurdle, especially in regions where DRI-EAF is not the lowest-cost production method. DRI-EAF can play an important transitional role, but its long-term competitiveness may be constrained by competing demand for natural gas and limited availability of high-quality scrap.

The Middle East and the United States are thus attractive locations for selected DRI-EAF investments, given their low natural gas prices and, in the case of the United States, ample high-quality scrap supply. Oman, which in this research is a proxy for the Middle East, produced three million tons of crude steel in 2024, all of it using EAF. The United States produced about 80 million tons in 2024, four percent of global production, 70 percent of which came from EAF production.[44]

Investment in DRI-EAF steel manufacturing in Europe relies on policy support. EU-27 carbon pricing under the EU Emissions Trading System (EU ETS) increases the costs of BF-BOF. This makes DRI-EAF production more attractive once allowances are phased out and ETS is in full force, or before that, enabling capture of a “green” premium.[45] Plans are already underway in Europe for more than 17 EAF and DRI-EAF steel plants that will produce roughly 40 to 50 million tons of low-carbon steel in 2030.[46]

Germany is at the forefront of Europe’s DRI-EAF steel transition, supported by heavy subsidies. Germany produced 37 million tons of crude steel in 2024, 2 percent of global production. Some 30 percent of that steel was produced using EAF.[47] The Salzgitter Salcos project is an early test case for converting an incumbent BF-BOF flat-steel production facility into a DRI-EAF plant that will eventually be powered by hydrogen, although the project has been delayed.[48] Sweden, a smaller steel producer at four million tons, is pursuing hydrogen-powered EAF via low-cost hydropower, though recent projects such as Stegra have struggled financially.[49]

In other regions, BF-BOF production linked to low-cost coal and strong domestic demand are a more attractive investment. This technology is dominant in markets such as India, China, and Southeast Asia, where natural gas and scrap availability are more limited. China accounts for around half of global output and is the main producer of the 600 million tons global overcapacity, so further capacity additions are likely to be modest.

DRI-EAF costs vary by half across locations, but BF-BOF in Asia undercuts all DRI-EAF costs

As part of our comparison of competitiveness across industries and regions, we isolate the drivers that explain why some regions are more or less competitive in a comparable technology. In this case, we recognize that actual steel investment decisions are influenced by a range of local factors.

For this purpose, we benchmark all locations against a common production route, DRI-EAF, and a common product, hot-rolled coil, in a plant with 2.5-million-ton capacity. This creates a like-for-like analytical baseline and allows us to compare the role of natural gas, electricity, raw materials, labor, logistics, and carbon costs in shaping regional competitiveness. In this benchmark, Oman is used as the base case because significant investments are underway there, including in Duqm and Sohar. We benchmark our base case against similarly sized factories using the same technology in China, Germany, India, Sweden, and the United States. Comparisons with other technologies and what drives actual investment decisions are addressed subsequently.

Sidebar

Methodology

This investment case compares the costs of a direct reduced iron–electric arc furnace, or DRI–EAF steel plant, in various geographies to understand what makes some regions more cost-competitive than others. Our levelized cost methodology converts a project's full life cycle economics into a single unit cost. It can be interpreted as the unit price that would make a project's net present value equal to zero over its entire life cycle, which is the minimum price that makes the project viable and is in line with the macroeconomic concept of long-term marginal costs. The concept is commonly applied in the energy sector, where it is known as the levelized cost of energy. We do not consider taxes, subsidies, and externalities, which vary and are hard to pin down.

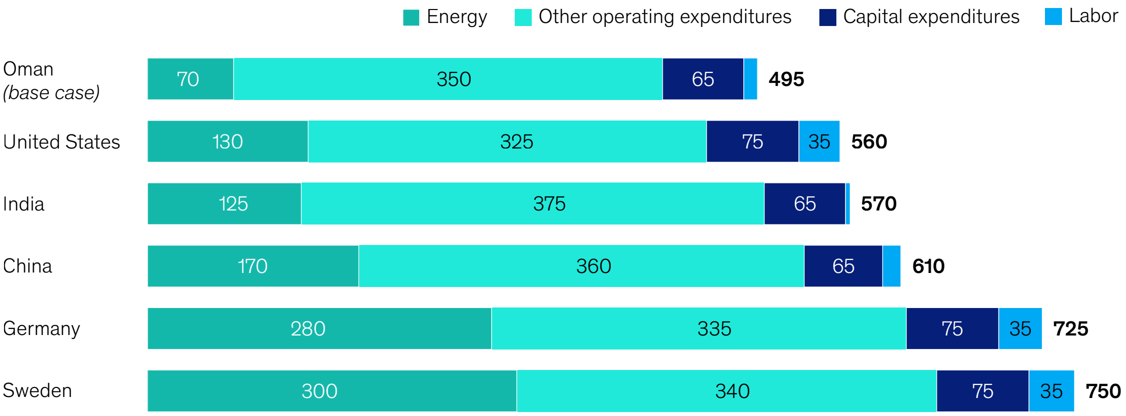
The calculations are informed by McKinsey's work across the steel industry, which provides our understanding of the capital expenditure, labor, energy, materials, and other inputs, as well as time, typically needed to build and operate a steel plant. We price the inputs at the typical costs in a geography, drawing on proprietary databases maintained by MGI's Economics Research team, and at the typical weighted average costs of capital, drawing on McKinsey's Value Intelligence platform, a curated database of the financials of companies globally.

Benchmark: Middle East (Oman)
The levelized cost of steel production measures the average cost of producing one ton of hot-rolled coil over the lifetime of a project. Across the six locations, levelized costs range from about $495 per ton in Oman to about $750 per ton in Sweden (Exhibit 2). The United States and India are the second- and third-most competitive locations, with approximately 10 to 15 percent higher levelized costs, respectively, compared to Oman. In China, DRI-EAF costs would be 25 percent higher than in Oman—certainly one reason the country has largely stuck to BF-BOF. The cost gap is materially larger in Europe, where levelized costs are 45 to 50 percent higher, mostly driven by higher natural gas prices.

Exhibit 2

Oman produces DRI–EAF steel at low cost, thanks to its low energy costs.

Levelized costs of DRI–EAF steel production,[1] $/metric ton, before taxes and direct subsidies



Note: Figures may not sum, because of rounding.

[1] Direct reduced iron–electric arc furnace (DRI-EAF) production of hot-rolled coil (HRC).

Source: S&P Global Market Intelligence; McKinsey Global Institute analysis

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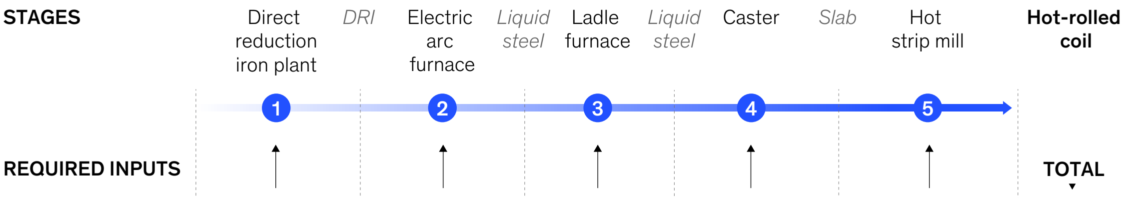
Energy costs (natural gas and electricity) are the main contributor to the gap in levelized cost between locations. For one ton of hot-rolled coil steel, about 11 gigajoules of natural gas is required, 70 percent of which is used in the DRI step. The electricity usage in the process is about 700 kilowatt hours, where about 70% is used to power the EAF. Overall, the DRI-EAF process uses about four to five times more energy from natural gas than from electricity (Exhibit 3).

Exhibit 3

Electricity powers the core melting step in steel production, and natural gas is the source of most energy in a DRI–EAF process.

DRI–EAF steelmaking process, required inputs per metric ton of hot-rolled coil



REQUIRED INPUTS	Direct reduction iron plant (1)	Electric arc furnace (2)	Ladle furnace (3)	Caster (4)	Hot strip mill (5)	TOTAL
Iron ore, metric ton[1]	1.2					**1.2**
Scrap steel, metric ton[2]		0.4				**0.4**
Electricity, kWh	80	500	30	10	100	**720**
Natural gas, kWh equivalent (GJ)[3]	2,240 (8.0 GJ)	280 (1.0)	56 (0.2)	140 (0.5)	420 (1.5)	**3,100 (11.2)**

Note: Inputs are assumed.
[1] In form of 68% Fe direct reduced pellets.
[2] Recycled steel.
[3] One gigajoule (GJ) of natural gas contains about 278 kilowatt-hours of energy.
Source: Global Materials Insights; McKinsey Global Institute analysis

McKinsey & Company

— *Gas costs:* The United States produces gas domestically and so has low gas costs similar to Oman. In Europe, however, the gas disadvantage is pronounced. Sweden's gas prices per ton were four to five times higher than Oman's in 2024. That added about $250, or 50 percent of Oman's total levelized cost, to the price of Sweden's steel, while Germany's gas costs per ton were two to three times higher, adding about 25 percent (Exhibit 4). Sweden's higher gas prices mainly stem from limited gas infrastructure low natural gas supply. China's and India's gas prices fall somewhere in the middle, with gas costs roughly double Oman's, increasing their steel prices by about 10 to 20 percent.

— *Electricity costs:* The cost of electricity varies by location. Sweden has very low electricity costs, mostly related to its use of hydroelectric power, which gives it about a 5 percent cost advantage relative to Oman.[50] Electricity costs in China, India, and the United States, are broadly in line with Oman's. Germany is the outlier, with electricity costs nearly double Oman's, adding a markup of $80 (15 percent) to a ton of its steel. This does not take into account subsidies for heavy industry in Germany, which lower electricity costs for individual producers.

Combined, Oman's total energy cost (natural gas and electricity) is more than four times lower than Sweden's and accounts for about 90 percent of the gap between the countries, or $230 of the total energy cost difference of $250 per ton of steel. Such a large difference is difficult to offset. Even when countries have other advantages, they cannot compensate for the energy cost gap.[51]

Labor costs also contribute to cost differences but to a substantially lower degree than energy because labor is a much smaller part of the overall costs in steelmaking. Salary differences account for most of the $20 to $30 additional cost of steel produced in Germany, Sweden, and the United States where salaries are roughly ten times higher than elsewhere. Chinese and Indian labor costs are consistent with Oman's and therefore do not meaningfully add to their cost gap.

Materials for steelmaking, including DR-grade pellets and scrap, are globally traded. In Germany, Sweden, and the United States, the cost per ton of steel is $20 to $30 lower than in Oman because their larger steel stock meant that more scrap is available. Oman, India, and China have a smaller steel stock, meaning less scrap is available and steel producers rely more on imported pellets. This means that advanced economies have a cost advantage in materials though not enough to offset the difference in energy prices.

Carbon pricing affects the EU-27, the only region where material CO_2 costs apply. That translates to cost per ton about $10 higher than in other regions. These costs increasingly penalize BF-BOF production and create a relative advantage for DRI-EAF production, as exceptions under the EU ETS are phased out and the EU Carbon Border Adjustment Mechanism is put into force. The exact cost premium will depend on the future structure of the European steel market, the availability and allocation of emissions allowances, and the prevailing carbon price. Due to the uncertainty of the carbon price development, this modeling uses the 2026 carbon premium.

Other factors, including capital expenditures, construction time, and maintenance costs, are largely similar across the countries because DRI-EAF is a relatively new technology and plants are expected to be built by the same original equipment manufacturer regardless of the location.

Exhibit 4

Energy costs determine the competitiveness of DRI–EAF steel production.

Levelized cost of DRI-EAF steel production,[1] $/metric ton, before taxes and direct subsidies

Note: Figures may not sum, because of rounding.

[1] Direct reduced iron–electric arc furnace (DRI-EAF) producing hot-rolled coil (HRC).

Source: McKinsey Global Institute analysis

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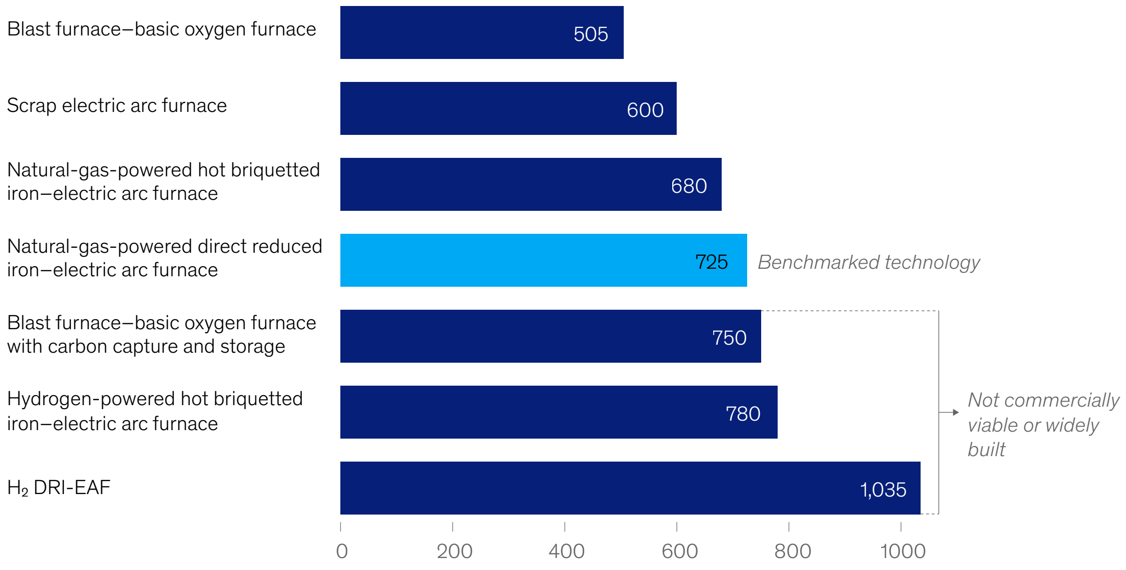
BF-BOF facilities in China and India are more competitive than DRI-EAF facilities in the Middle East (Oman)

The cost structure of steel production has a direct impact on which technologies are likely to be deployed across regions. Where low-cost gas is available, such as in the Middle East and the United States, DRI-EAF plants can be competitive. Where it is not, countries default to BF-BOF as in China and, increasingly, India—unless forced or given incentives to decarbonize, as in Europe. Comparing the full range of technologies for Germany, the most expensive technology, hydrogen-powered DRI-EAF, is twice as expensive as the cheapest one, BF-BOF (Exhibit 5).

Exhibit 5

DRI-EAF steel production is about 50 percent more expensive in Germany than traditional BF-BOF production.

Levelized cost of steel in Germany among different production pathways,[1] $/metric ton of flat steel, before taxes and direct subsidies



[1] Higher-quality scrap price and other necessary DRI inputs to create flat steel are likely not priced in and would increase levelized costs.
Source: McKinsey Global Institute analysis

McKinsey & Company

Oman is no longer the lowest-cost benchmark when BF-BOF is included (Exhibit 6). In India, BF-BOF production drops levelized cost by about 35 percent, from $570 ton to $380 per ton. Thus, Indian steel produced in a BF-BOF plant costs $120 less per ton than steel produced in Oman with DRI-EAF. Similarly, BF-BOF steel production in China reduces levelized cost by about 20 percent, from about $610 per ton to $480 per ton, making China's steel about $15 cheaper per ton than Oman's. India and China thus are the most cost competitive in steel in our benchmark.

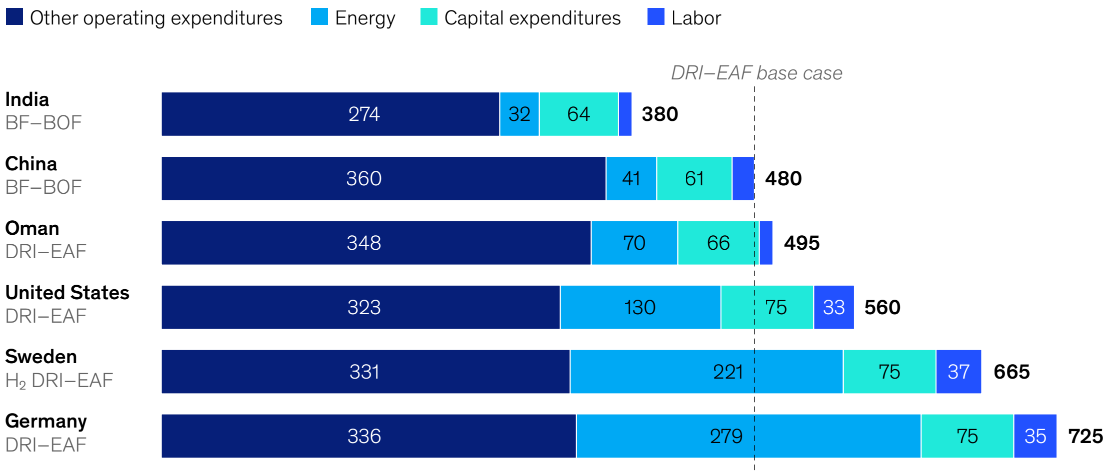
In Sweden, efforts are underway to use low-cost hydropower for hydrogen-powered DRI EAF, such as in the Stegra facility currently under construction in Boden. Switching from DRI-EAF production powered by natural gas to hydrogen-powered DRI-EAF production could drop Sweden's levelized cost from $750 to $665 per ton.[52] Even so, steel produced in Sweden's hydrogen-powered DRI-EAF plants costs $170 more per ton than steel produced in Oman and $285 more per ton than steel out of India's BF-BOF plants.

For investors, these different technology paths imply three investment paths. First, investment driven by cost remains centered on BF-BOF in India and China. Producers there can deliver the lowest-cost steel, which comes with the highest CO_2 emissions. Second, transition-positioned investment favors DRI-EAF in the Middle East and the United States, where gas economics work without subsidies. Third, policy-dependent investment centers on DRI-EAF or hydrogen-powered DRI-EAF in Europe, viable only as carbon prices rise and free allowances are phased out, or as equivalent subsidy, green-premium support, or both are secured. Each archetype implies different return expectations, risk profiles, and sustainability and policy exposure.

Exhibit 6

Methods of producing hot-rolled coil steel are most competitive in China and India.

Levelized cost to produce hot-rolled coil across different technologies, $/metric ton, before taxes and direct subsidies



Note: The chart features the dominant or illustrative production method for each country, including blast furnace–basic oxygen furnace, direct reduced iron–electric arc furnace, and hydrogen-powered direct reduced iron–electric arc furnace methods.
[1] Figures may not sum precisely, because of rounding.
Source: S&P Global Market Intelligence; McKinsey Global Institute analysis

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Cost will drive steel investment, but policy will also determine where investment lands

Steel production will remain primarily a cost game. Purchases of flat steel are still driven mainly by price, quality consistency, and supply-chain reliability rather than by production method. However, policy is increasingly shaping investment decisions for geostrategic or environmental reasons. This is already altering regional investment patterns, especially in Europe and the United States. Lower-emissions steel will scale fastest where policy support, input economics, and technological readiness reinforce one another. Over time, technology could materially reshape the cost curve, narrowing the cost gap with incumbent production routes and making lower-emissions steel competitive across a broader set of regions.

In the United States, Section 232 tariffs increase import prices and so support domestic steel production.[53] Products made entirely from steel—for example, steel coil—carry a flat 50 percent tariff, with a flat 25 percent of full value imposed on derivative articles made of steel such as steel kitchen stoves. In the EU-27, steel imports that exceed certain quotas are subject to a 50 percent tariff.[54] In India, domestic preference rules prioritize locally produced steel in public projects, which limits imports.

Carbon regulations and subsidies are particularly important in Europe. The EU ETS system adds costs especially to BF-BOF production. Because the ETS benchmark is anchored in BF-BOF performance, low-emissions DRI-EAF plants can gradually improve their relative cost position and create economic surplus as BF-BOF allowances phase out over time and cleaner technologies scale. The EU Carbon Border Adjustment Mechanism is designed to level the playing field also charging carbon pricing on imported steel, but this will still increase the steel price in Europe.

The steel industry is heading into dynamic times. Cost competitiveness will remain the starting point, but energy prices, carbon regulation, trade policy, and technology will increasingly determine which production routes scale and where. Regions where energy is structurally expensive, like in Europe and advanced Asia, could relocate the production step requiring in the most energy to regions with more abundant energy resources. For DRI-EAF, this would mean relocating DRI production to lower-cost regions like the Middle East or the United States while maintaining the EAF step as well as rolling and finishing the product nearer to demand. How quickly producers, policymakers, and customers align on costs, carbon emissions, and demand will determine the competitiveness of steel produced with lower emissions.

Karel Eloot is a McKinsey senior partner based in the Shenzhen office, **Jeffrey Lorch** is a McKinsey partner based in the Boston office, **Anna Kortis** is a McKinsey partner based in the Vienna office, **Olivier Bus** is a consultant based in the Amsterdam office, and **Dirk Durinck** is a senior expert in the Brussels office.

Investment case

Polyethylene: Widely produced—but not one-size-fits-all

Manufacturing polyethylene is a highly competitive business. Success depends greatly on access to feedstocks, yet investment doesn't always follow economics.

by Eren Cetinkaya, Axel Spamann, Jonas Oxgaard, Anna Kortis, and Olivier Bus

If you went grocery shopping today, washed dishes, or installed wiring, chances are you came in contact with polyethylene (PE). PE is the most widely produced plastic in the world, used in packaging, construction materials, medical devices, and industrial products, among other things. Its durability, versatility, and low cost make it a foundational input in modern economies, and demand for it is closely tied to population growth, urbanization, and consumer goods consumption. As demand expands in emerging economies and global supply chains evolve, a central question is where new manufacturing capacity will be located in this highly competitive commodity industry. Competitiveness is shaped by access to feedstock, financing conditions, and industrial policies, but this is not a one-size-fits-all story.

The investment case is one of ten used in the research for the McKinsey Global Institute's report, *Catalyzing competitiveness: Where businesses invest and why*. The report examines how variations in the basic economics of comparable projects influence investment decisions in different regions globally and the impact those decisions can have on the future of competitiveness and growth across the world.

Polyethylene is the most widely produced plastic in the world

PE comprises several product types, each with a distinct end use. Most notable are high-density polyethylene (HDPE), which is used in rigid applications such as containers and pipes, and low-density variants that are used in flexible films like food packaging. The broader chemicals sector currently accounts for about $500 billion in global investment, reflecting the scale of the industry.[55]

Today, global installed capacity can produce roughly 150 million metric tons of PE per year. Before 2020, demand grew at about 3 percent annually. Over the past several years, growth in the industry has slowed to roughly 1 to 2 percent per year, but most long-term scenarios suggest that annual demand growth will rebound to about 3 percent, approaching 200 million tons annually by 2035 primarily due to demand in emerging markets. Meeting this demand would require ten to 25 new world-scale crackers, which are the large industrial plants that convert oil- and gas-based feedstocks into ethylene, the key building block of PE.[56]

Polyethylene is produced using ethane-based and naphtha-based routes

Two types of ethylene production exist, ethane-based and naphtha-based processes. Ethane is a light hydrocarbon extracted from natural gas liquids (NGL). Ethane can be significantly cheaper in NGL-rich regions such as the US Gulf Coast and parts of the Middle East because local supply is abundant whereas moving ethane to other markets requires dedicated and costly infrastructure, including pipelines, refrigerated storage, and specialized shipping. Naphtha, by contrast, is an easily transported liquid traded in global markets, so its price is more internationally integrated and typically less discounted regionally than ethane. PE production in regions like China, Europe, Japan, and South Korea is primarily naphtha-based.

Because PE production technology is mature and widely standardized, competitiveness typically depends less on process innovation and more on structural advantages such as access to low-cost ethane feedstock. Currently, ethane-advantaged regions operate as export hubs. For example, North America exports more than 40 percent of its PE production, primarily to Asia and Europe, according to McKinsey analysis.

However, limited supply constrains ethane economics. For example, in the Middle East, governments allocate access to ethane, effectively making feedstock availability dependent on local industrial and resource allocation decisions. In the United States, by contrast, ethane is market-priced; if new crackers are built faster than the supply of ethane grows, or if export capacity keeps expanding and pulls more supply into global markets, ethane prices can rise and margins shrink. This creates an asymmetric global supply structure. Ethane itself may be low cost, but its price doesn't determine the global market price for PE because volume is limited. As demand grows, especially in Asia, incremental supply will still require higher-cost naphtha-based production.

Importantly, even if sufficient ethane were available, ethane cracking cannot fully replace naphtha cracking in the broader petrochemical ecosystem. Ethane cracking is highly efficient for producing PE but generates limited byproducts. By contrast, naphtha cracking produces a range of byproducts that are essential inputs for materials such as rubbers, synthetic fibers, engineering plastics, and insulation.[57]

Naphtha cracking therefore has a structural role beyond PE production. As electrified transportation increases, declining oil refining could reduce the supply of naphtha. This, in turn, constrains the availability of critical petrochemical byproducts, particularly aromatics. While these materials can be produced through alternative processes, doing so is typically more costly and adds complexity compared to integrated naphtha cracking. Global competitiveness therefore cannot be assessed solely through ethane or PE economics, since the broader petrochemical ecosystem depends on a diversified feedstock mix.

China is the biggest investor in polyethylene manufacturing while Europe could reposition much of its production

China accounts for the largest share of PE production capacity and investment, despite its processes being predominantly naphtha-based and so higher cost (table). This capacity is mostly linked to national oil companies, as well as other smaller private players. China's plans to increase domestic production could move it toward self-sufficiency by 2030 if planned projects come to fruition.[58] This has two potential implications: Global trade flows, especially from Middle Eastern and US export destinations, may shift significantly, and global capacity additions may exceed demand, pressuring margins even for competitive exporters.

Table

Current polyethylene capacity and planned additions by country

Country (primary region)	Installed capacity (million tons per year, 2025)	Capacity additions (million tons per year, 2025-2030)[1]
China	42	23
North America	34	2.3
Middle East	23	6.8
Western Europe	14	0.2
Global	156	31

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[1] Figures represent nameplate (design) capacity. Actual output is lower and depends on operating rates.

Capacity growth in the Middle East and North America reflects those regions' underlying advantages, particularly access to low-cost ethane. Europe is moving in the opposite direction, with limited new investment. Up to five million tons of yearly capacity of existing European ethylene plants could be phased out over the next five years.[59] This reflects not only weaker feedstock competitiveness but also higher capital costs, longer and less predictable permitting timelines, and growing regulatory and societal constraints on plastics.

Overall, while investment in PE production generally follows cost competitiveness, China stands out as a major exception, accounting for a disproportionate share of new capacity despite challenging underlying economics.

Costs in naphtha-based regions are twice as high as in ethane-based regions

This case is based on a world-scale one-megaton-per-year ethylene cracker with an integrated 400-kiloton-per-year HDPE unit, operating at 90 percent utilization, consistent with the typical scale of modern, greenfield developments.[60]

The Al Jubail facility in Saudi Arabia is used as the base case because it illustrates the combination of low-cost ethane feedstock and mature industrial infrastructure, and it has proven execution capabilities. (The facility's output was reduced during the war in the Persian Gulf in 2026.) We compare it to similar polyethylene investments in China, Germany, and the United States (see sidebar, "Methodology").

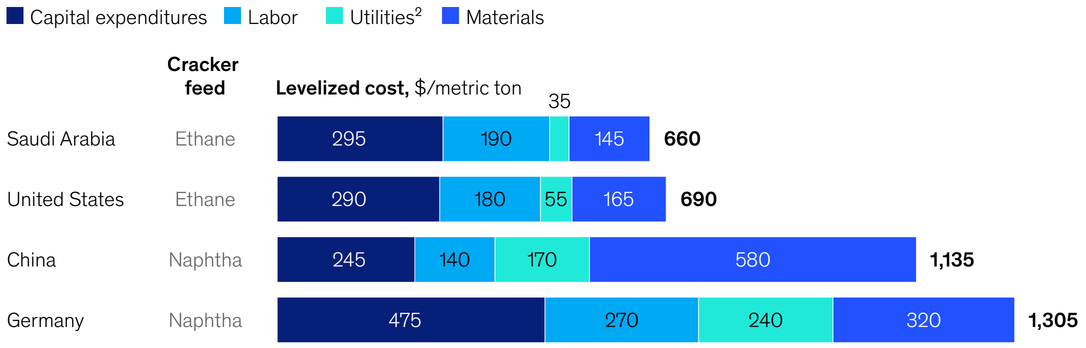
Benchmark: Saudi Arabia (Al Jubail)
The levelized cost of a facility like Al Jubail measures the average cost of producing one ton of PE over a facility's lifetime, representing the breakeven selling price that yields zero net present value at the assumed discount rate. In Saudi Arabia it is about $660 per ton, the lowest

cost in its peer group. Capital expenditures such as construction and equipment account for about half of the total levelized cost in Al Jubail (Exhibit 1). These costs include construction labor as well as investment in core processing equipment and supporting infrastructure. Operating costs such as labor, feedstock, utilities, and other expenses like insurance make up the remainder of the levelized cost.

Exhibit 1

Capital expenditures account for the greatest share of costs in polyethylene manufacturing except in China, where feedstock is the biggest cost.

Levelized cost of polyethylene production per component,[1] $/metric ton, before taxes and direct subsidies



[1] We consider a 400-kiloton per year high-density polyethylene plant fed by an ethane or naphtha cracker.
[2] Raw material costs are net of byproduct credits.
Source: S&P Global Market Intelligence; McKinsey Global Institute analysis

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Sidebar

Methodology

This investment case compares the costs of a polyethylene project across various geographies to understand what makes some regions more cost-competitive than others. Our levelized cost methodology converts a project's full life cycle economics into a single unit cost. It can be interpreted as the unit price that would make a project's net present value equal to zero over its entire life cycle, which is the minimum price that makes that project viable and is in line with the macroeconomic concept of long-run marginal costs. The levelized cost concept is commonly applied in the energy sector, where it is known as the levelized cost of energy. We do not consider taxes, subsidies, and externalities, which vary and are hard to pin down.

The calculations are informed by McKinsey's work in the chemicals industry, which provides our understanding of the capital expenditure, labor, energy, materials, and other inputs, as well as time, typically needed to build and operate a polyethylene plant. We price the inputs at the typical costs in a geography, drawing on proprietary databases maintained by MGI's Economics Research team, and at the typical weighted average costs of capital, drawing on McKinsey's Value Intelligence platform, a curated database of the financials of companies globally.

Feedstock costs are the major driver of variation across geographies
In the regions compared, levelized costs range from $660 per ton of PE in Saudi Arabia to almost double, $1,305 per ton, in Germany (Exhibit 2). Cross-country comparisons of PE economics are therefore most useful when they distinguish between the two production processes.

Exhibit 2

Feedstock and utility costs account for the variation in the costs of polyethylene production across countries.

Levelized cost of polyethylene,[1] $/metric ton, before taxes and direct subsidies

Note: Numbers may not sum precisely due to rounding.
[1] We consider a 400-kiloton per year high-density polyethylene plant fed by an ethane or naphtha cracker.
Source: S&P Global Market Intelligence; McKinsey Chemicals Practice; McKinsey Global Institute analysis

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Raw materials are the main source of cost variation. Ethane-based producers in Saudi Arabia and the United States benefit from access to locally priced ethane. In contrast, producers in China and Germany rely on naphtha, which is globally traded and typically more expensive. As a result, raw material costs net of byproduct credits in naphtha-based systems today are more than three times those of ethane-based producers, on average $450 per ton versus $160 per ton, accounting for roughly a third of of the cost difference of ethane-based suppliers to Germany and explaining 90 percent of the difference to China.

The advantage of ethane-based producers stems not only from process economics but also from the broader structure of gas markets. In regions such as Saudi Arabia and the US Gulf Coast, natural gas and NGLs are locally abundant and costly to transport over long distances. Converting gas into petrochemicals is thus a means of monetizing stranded or regionally discounted resources, which lowers feedstock and utility costs in regions with abundant gas resources.

Utilities are the second-largest driver of cost differences and amplify feedstock disadvantages. While energy usage may not differ dramatically between ethane and naphtha, naphtha-based plants produce a wider range of byproducts alongside PE. Naphtha cracking produces significant fuel gas used in the process itself, but the energy required for polyethylene production and further processing of byproducts can increase overall energy requirements for fully integrated, naphtha-based plants. As a result, fully integrated naphtha-based plants tend to consume more energy overall. In regions that rely on imported fuels or globally priced energy, this can translate to utility costs five to seven times as high as those in Saudi Arabia. Utility cost differences account for about 25 percent of the variation in costs across regions.

Capital expenditures drive about 25 percent of the variation in costs. Germany has materially higher capital expenditures, $475 per ton compared to $290 per ton in the United States, because it uses naphtha cracking, which requires more complex equipment than ethane cracking. China's capital expenditures of $245 per ton are materially lower, which reflects its lower construction and labor costs, standardized designs, and domestic equipment supply chains.

China's PE investments have had low returns

PE is a globally traded commodity but is not sold at a single, uniform global price. While arbitrage can narrow differences in regional prices over time, price gaps typically persist due to freight and delivery terms, duties, product specifications, inventory cycles, regional market concentration, and trade barriers. Potential returns can be assessed using regional pricing rather than a standard market price.

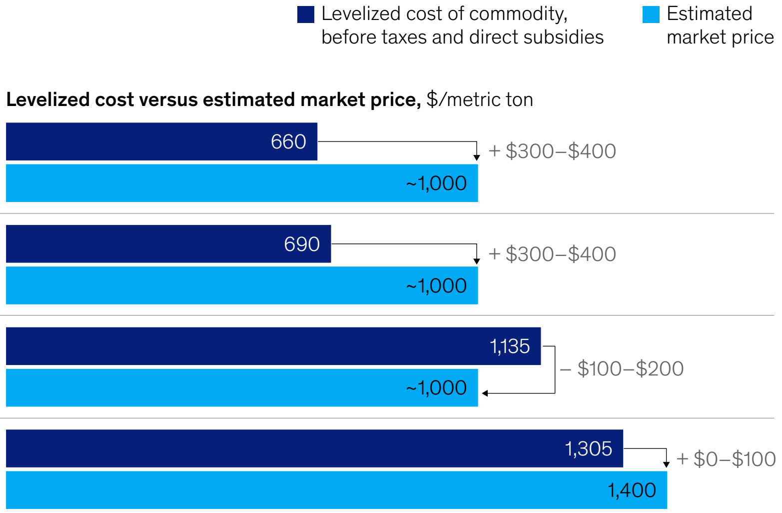
In ethane-advantaged regions such as Saudi Arabia and the United States, export prices were about $1,000 per ton in 2025, implying an internal rate of return ranging from 10 to 15 percent compared to a levelized cost of $660 to $690 per ton. In Germany, higher regional prices of about $1,400 per ton of PE were offset by a similarly high levelized cost, implying an internal rate of return close to an 8 percent discount rate. China has a levelized cost of $1,135 per ton, compared to PE prices of about $1,000 per ton, implying returns at 1 to 2 percent, well below the discount rate typically expected by private investors (Exhibit 3).

Exhibit 3

Return expectations determine the viability of an investment in polyethylene manufacturing.

Comparison of high-density polyethylene levelized cost and estimated market price

	Cracker feed	Implied project internal rate of return, %
Saudi Arabia	Ethane	10–15
United States	Ethane	10–15
China	Naphtha	1–2
Germany	Naphtha	8–10



Note: Integrated high-density polyethylene production assumes a 400-kiloton per year ethane or naphtha cracker.
Source: McKinsey Global Institute analysis

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These differences can shed light on observed investment patterns. Strong returns could explain continued expansion in Saudi Arabia and the United States, while weaker returns may limit investment in Germany. China, however, breaks with the pattern. Despite low returns, it continues to add substantial capacity.

This divergence reflects differences in investor objectives. The 8 percent cost of capital reflects a typical private-market cost of capital. In China, however, most PE investment is state-driven. State-owned enterprises have added the majority of new PE capacity. Moreover, many new Chinese crackers are integrated with refining operations, giving investors access to profit margins across the full value chain rather than relying on PE economics alone.[61]

State-owned enterprises typically consider broader strategic goals such as industrial development and self-sufficiency over project-level returns. In that context, PE investment may proceed even when returns are low because the objective is partly to generate wider economic spillovers and resilience that private investors alone might not fund.

Compete on cost or alter the market

The key question for potential PE players is how to position themselves in a market where the basis of competitiveness differs so structurally by region. In ethane-advantaged regions, projects rely on maintaining cost advantages and managing exposure to global price cycles. By contrast, production in higher-cost regions is typically viable only when supported by local demand or favorable regional pricing.

In those higher-cost regions, the investment decision is often whether to reinvest in existing assets. Ethylene crackers require major refurbishment, which can cost hundreds of millions of dollars, every four to six years. Operators in Europe are increasingly deciding not to reinvest, shutting down crackers while continuing to run downstream PE assets using imported ethylene.[62] This reflects a shift away from fully integrated production and toward more flexible models.

Additionally, competing in commodity PE is difficult, so higher-cost regions could shift production into areas where pricing is less globally arbitraged. Then, rather than trying to make the cheapest plastic, PE manufacturers could focus on making plastic that customers are willing to pay more for, whether through improved performance for specific applications or through materials with recycled content or lower emissions.

For policymakers, the implication is similar. In some cases, importing PE is the more efficient outcome, but domestic production may still matter for broader strategic goals. Thus, policy may play a more active role in higher-cost regions. Demand mandates like recycled content requirements can create guaranteed demand for specific types of PE. Waste regulations like restrictions on landfills or incineration increase the supply and use of recycled plastics. Carbon-related measures like carbon pricing and border adjustments can raise the cost of more emissions-intensive production.

Such policies can shift demand toward forms of PE that are not fully interchangeable with standard PE. This creates segments of the market where competition is based less on cost and more on sustainability or regulatory requirements, potentially allowing domestic producers to compete on different terms.

Polyethylene is a cost-driven industry at its core, but the terms of competition are not fixed. Regions that cannot compete on feedstock cost alone are finding ways to stay in the game, whether through value chain integration, product differentiation, or policy.

Eren Cetinkaya is a McKinsey partner based in the Istanbul office, **Axel Spamann** is a partner based in the Hamburg office, **Anna Kortis** is a partner based in the Vienna office, **Olivier Bus** is a consultant based in the Amsterdam office, and **Jonas Oxgaard** is a senior expert based in the New York office.

The authors of the McKinsey Global Institute report, *Catalyzing competitiveness: Where investment happens and why*, would also like to thank Arjun Padmanabhan and Adam Youngman for contributing to this research.

Investment case

Pharmaceuticals: Innovating and advancing around the world

The continued rise of monoclonal antibody therapies and demographic changes are powering growth in the pharmaceuticals industry.

by Frédéric Remond, Norman Carra, Vivek Arora, Anna Kortis, and Olivier Bus

Humans have relied on drugs to overcome illness and extend health and wellbeing for almost as long as they've walked planet Earth. The roots of morphine date back some 8,000 years, and penicillin, discovered in 1928, still saves lives by killing deadly bacteria. More recently, GLP-1 therapies promise to ameliorate heart disease, lower blood pressure, and reduce other chronic health issues. Monoclonal antibodies are a major class of biologic drugs and play a particularly important role in cancer treatment. As the global population ages and more people have chronic diseases, demand for pharmaceuticals will continue to increase. At the same time, advances in AI are accelerating drug discoveries. Together, this means investment in the industry will likely continue to grow, and what follows examines what it takes to manufacture monoclonal antibody therapies competitively.

The investment case is one of ten used in the research for the McKinsey Global Institute's report, *Catalyzing competitiveness: Where investment happens and why*. The report examines how variations in the basic economics of comparable projects influence investment decisions in different regions globally and the impact those decisions can have on the future of competitiveness and growth across the world.

The pharmaceutical market is growing faster than global GDP, with a growing role for biologics

Steady demand growth and shifts in underlying technologies propel pharmaceutical manufacturing. Changing demographics mean the global median age is projected to rise by about five years between now and 2050, which is expected in turn to increase global pharmaceutical sales at about 5 percent CAGR a year.[63] Additionally, an increase in the number of people with chronic diseases, a corollary of demographic trends, points to long-term demand for medicines.

The pharma supply chain typically starts with research and development (R&D), including discovery, preclinical work, and clinical trials prior to regulatory approval. This phase can last as long as two decades. Patent protection is typically filed during drug development and, once obtained, lasts 20 years from the filing date. Because a portion of this 20-year period is consumed by development and regulatory review, the effective commercial exclusivity window following regulatory approval shrinks. These long timelines and finite exclusivity periods mean that time is of critical importance in the R&D stage of pharmaceutical investments.

Downstream from R&D, manufacturing is generally split into two stages, drug substance, or production of an active ingredient, and drug product, which is when a drug is formulated into its final, patient-ready form. Drug substance and drug product manufacturing may take place at the same facility or at different sites and can occur in-house or be outsourced to contract development and manufacturing organizations (CDMOs).

Additionally, the pharmaceuticals industry distinguishes between small-molecule conventional drugs and larger-molecule biologic drugs. Biologics span multiple modalities, including monoclonal antibodies, cell and gene therapies, and other complex biologics and have different manufacturing processes and regulatory requirements. Innovation has steadily increased the market share of such advanced therapies from 30 percent of overall pharma sales in 2018 to more than 40 percent in 2024, a proportion expected to increase to roughly 45 percent by 2030. Biologics typically command higher gross margins than small-molecule drugs, reflecting greater clinical differentiation and pricing power as well as greater manufacturing complexity.

Monoclonal antibodies (mAbs) are a major class of biologics. These antibodies are immune proteins with high molecular weights that are produced in living cell cultures and designed to bind to specific biological targets, modulating the immune system, blocking signals, or targeting destruction of diseased cells. They are used in many therapeutic areas, including oncology, immunology, and treatment of autoimmune and inflammatory diseases, and they play a particularly big role in cancer treatment. Among advanced biologic modalities, monoclonal antibodies account for a major share of the biologics market; global therapeutic antibody sales exceeded $267 billion in 2024.[64]

Europe and the United States remain major pharma manufacturing hubs, but US investment is pulling ahead

Pharmaceutical gross value added (GVA) is historically concentrated in Europe and the United States.[65] The EU-27 and the United States each account for roughly 30 percent of global pharmaceutical GVA, and China for roughly 20 percent. In investment terms, the United States represents about 30 percent of global gross financial capital formation, compared to 25 percent each for China and Europe.[66]

Recent greenfield announcements, however, suggest that the US share of advanced pharmaceuticals manufacturing could be growing. Greenfield expansions announced totaled about $18 billion in 2024 and jumped to $180 billion in 2025, according to McKinsey analysis. This step change in announced investment is associated with recent policy measures aimed at strengthening domestic manufacturing, including tariffs and trade restrictions for imported drugs.

Materials and labor costs determine costs in any one location, with wage differentials driving differences between locations

The investment case is based on a drug substance facility manufacturing monoclonal antibodies with an annual capacity of 1,200 kilograms. The findings may extend to other innovative modalities, such as cell and gene therapies that have similar dynamics, but are less relevant for generics, for which cost is the overriding factor due to rapid price erosion. China is the base-case location, reflecting its lower manufacturing costs and growing investment share. It is compared against similarly sized facilities using comparable technologies in Eastern Europe, Germany, and the United States, using a like-for-like comparison of levelized costs.

The levelized cost of drug substance manufacturing, which measures the average cost of production over the lifetime of a facility, is driven by a small number of items. Operating expenses dominate. Materials contribute most to costs, reflecting the use of cell culture media, resins, and single-use consumables in upstream and downstream processing, accounting for about 30 percent of the levelized cost in the base case (see sidebar, “Methodology”). The findings of this case may extend to other innovative modalities such as cell and gene therapies, which have similar dynamics, but are less relevant to generics, for which rapid price erosion makes cost the overriding factor.

Exhibit 1

Labor costs account for as much as 65 percent of the variation in costs for pharmaceutical plants across countries.

Levelized costs of producing a monoclonal antibody drug substance,[1] $ thousand/kg, before taxes and direct subsidies

Note: Figures may not sum, because of rounding.

[1] 1,200 kg monoclonal antibody drug substance.

Source: McKinsey Global Institute analysis

McKinsey & Company

Sidebar

Methodology

This investment case compares the costs of a drug substance facility manufacturing monoclonal antibodies across various geographies to understand what makes some regions more cost competitive than others. Our levelized cost methodology converts a project's full life cycle economics into a single unit cost. It can be interpreted as the unit price that would make a project's net present value equal to zero over its entire life cycle, which is the minimum price that makes that project viable and is in line with the macroeconomic concept of long run marginal costs. It is also in line with the macroeconomic concept of long-term marginal costs. The levelized cost concept is commonly applied in the energy sector, where it is known as the levelized cost of energy. We do not consider taxes, subsidies, and externalities, which vary and are hard to pin down.

The calculations are informed by McKinsey's work in the pharmaceuticals industry, which provides our understanding of the capital expenditure, labor, energy, materials, and other inputs, as well as time, typically needed to build and operate a facility making monoclonal antibodies. We price the inputs at the typical costs in a geography, drawing on proprietary databases maintained by MGI's Economics Research team, and at the typical weighted average costs of capital, drawing on McKinsey's Value Intelligence platform, a curated database of the financials of companies globally.

Wage differentials drive variations in manufacturing costs between regions more than any other factor

Labor costs are the biggest contributor to cost differences in drug substance manufacturing of monoclonal antibodies around the world, accounting for about 60 to 65 percent of the levelized cost difference between China and Germany and the United States (exhibit). Because productivity levels are very similar in state-of-the-art plants, these differences are linked primarily to wages. In the United States, wage differences account for essentially the entire labor cost gap with China. When comparing Germany and China, Germany's productivity is about 10 percent higher. Yet its higher wages result in operating labor costs that are approximately 85 percent greater than China's. China and Eastern Europe have only limited differences in labor costs overall, with similar wage levels and productivity.

Materials are the second-largest driver of levelized cost differences, contributing about 20 percent of the levelized cost gap. This reflects pricing pressure and a mix of sourcing strategies in the base case, including imported materials, materials manufactured locally in China by multinational companies, and locally sourced materials. By contrast, Europe and the United States are assumed to source largely from global suppliers and so pay broadly comparable prices.

Construction costs represent another meaningful source of variation in levelized cost in drug substance manufacturing of monoclonal antibodies. Differences arise from higher construction and project execution costs and from variation in time to market. Differences in construction time are mainly the result of regulatory requirements. Construction productivity is higher in Asia, while regulatory complexity in European and US markets often leads to costlier designs and longer construction periods. In China, faster permitting and approval timelines can further shorten construction timelines compared to Europe and the United States. Overall, construction cost differences account for about 5 percent of the levelized cost gap and have the largest impact in the United States.

Time-to-market differences account for an additional 5 percent of the cost gap in our example. Given that the monoclonal antibodies that are a product of drug substance manufacturing are an input for patented drugs and that effective commercial exclusivity typically ranges from 10 to 14 years following approval, construction delays can compress the commercialization window, cutting into revenues and profits. The commercial impact of time-to-market differences can vary depending on the product and market context. In oncology and immunology markets, where monoclonal antibody therapies often include high-revenue products, delays in securing manufacturing capacity may limit supply during peak launch periods, with implications for market penetration and revenue capture. In other situations, companies may mitigate timing risk by outsourcing initial volumes to CDMOs or leveraging existing manufacturing networks, in which case the impact is more limited and primarily reflected in margin dilution rather than lost sales.

Taxes and subsidies are not modeled here but can also play an important role in the economics of the drug substance manufacturing of monoclonal antibodies. Incentives for pharmaceutical manufacturing typically include fiscal and tax measures, capital grants, operating subsidies, and preferential financing. These incentives can influence decisions at two levels. At a country level, governments may offer targeted packages as part of broader strategies to attract pharma manufacturing and innovation. Once a country is selected for investment, local authorities can offer materially different incentives that shape the choice between cities or regions within that country. Given the project-specific nature and high variability over time and across locations of incentives, they are not explicitly reflected in our core levelized cost modeling. Nevertheless, they can materially affect individual business cases and final site selection decisions.

Technology and AI are increasingly playing a role in tackling these cost differences. Biologic manufacturing is inherently complex, with hundreds of variables that affect cost, quality, and productivity. Using automation and AI to manage that complexity is becoming a source of competitive advantage that is most valuable where labor is expensive. As investment flows into the United States, where labor costs are high, sites that can operate with greater autonomy become even more important. Deploying AI and automation at scale can offset the labor cost disadvantage.

Pharmaceutical intermediates are priced on the world market, offering limited differentiation

The value of monoclonal antibodies manufacturing is not determined by end-market pricing. Drug substance manufacturing is an intermediate input in the production of finished biologics and is typically transferred internally within a company's manufacturing network or supplied under long-term business-to-business contracts. As a result, drug substance manufacturing of monoclonal antibodies does not generally have a geography-specific market price. In practice, however, lower-cost countries may offer discounts to international buyers, reflecting domestic price pressures and lower local market price expectations.

By contrast, pricing dynamics differ at the level of finished biologics. Final drug prices vary significantly across geographies, with the highest monoclonal antibody prices in the United States and lower prices in Europe and China due to differing reimbursement, negotiation and reference-pricing mechanisms.[67] These differences affect overall product-level returns but do not directly translate into differences in drug substance manufacturing economics.

Industrial policy and strategic priorities are increasingly shaping the investment footprint

Cost competitiveness remains relevant to pharmaceutical manufacturing location decisions, but recent investment patterns—particularly over the past two years—are better explained by strategic considerations than by cost alone. While China's unit costs are low, investment in higher-value biologics manufacturing today is still concentrated in Europe and the United States, reflecting the importance of regulatory credibility and strong intellectual property protection, as well as reliable execution and proximity to leading innovation ecosystems.

For biopharma executives, widening cost differentials point to a broader shift in manufacturing competitiveness. The traditional logic of optimizing for labor and operating costs alone when allocating capital is no longer sufficient. Investment decisions increasingly reflect a resilience premium that incorporates supply-chain security, speed to market, and evolving industrial policies. For complex biologics, manufacturers often prioritize locations near R&D, clinical development, and technical talent, where colocation can accelerate process development, support faster scale-up, and improve coordination across technical, regulatory, and commercial teams during launch. These advantages can outweigh moderate operating cost differences, especially innovative or high-value products that require speed, reliability, and quality consistency. In this context, the higher costs of established biopharma hubs can be viewed as an ecosystem premium, providing access to experienced operators, CDMOs, specialized suppliers, regulatory expertise, and manufacturing know-how. To remain competitive, companies will need to complement these advantages with advanced manufacturing technologies, including AI and automation, that raise productivity and reduce reliance on labor. The leaders of the next decade are likely to be those that move beyond purely cost-optimized footprints and build manufacturing networks that balance efficiency, innovation, and resilience.

Public policy and geopolitics further reinforce this shift. In the United States, initiatives to strengthen domestic biopharmaceutical supply chains have increased incentives to manufacture for local markets. In Europe, selective grants and strategic programs support domestic production in specific cases. These dynamics are making cost an important, but increasingly secondary, factor in manufacturing footprint decisions.

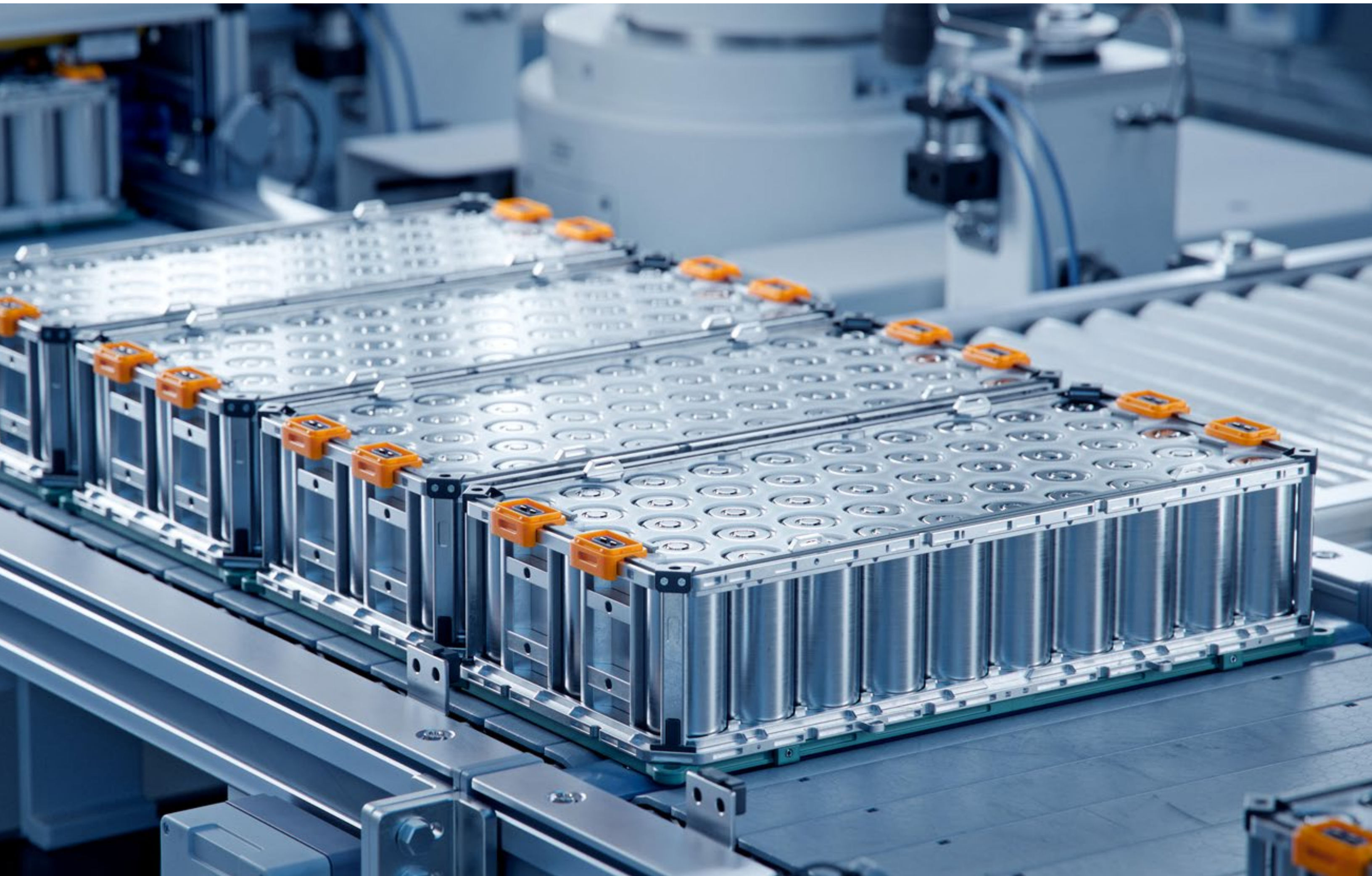
Frédéric Remond is a McKinsey partner based in the Zurich office, **Norman Carra** is a partner based in the Montreal office, **Vivek Arora** is a partner based in the Boston office, **Anna Kortis** is a McKinsey partner based in the Vienna office, and **Olivier Bus** is a consultant based in the Amsterdam office.

Investment case

Batteries: Scaling the engine of electrification

Demand for batteries is surging as electric vehicles and storage grow, but competitiveness depends on securing materials, ramping up gigafactories, and building the local ecosystems needed to compete.

by Martin Linder, Jakob Fleischmann, Anna Kortis, and Olivier Bus



Battery production has scaled at an extraordinary speed, supported by rising demand for electric vehicles and stationary storage, with demand for lithium ion phosphate batteries totaling almost 1.6 terawatt-hours in 2025.[68] This scale-up has delivered one of clean technology's most dramatic cost reductions: Utility-scale battery storage costs have fallen by about 93 percent since 2010, driven by growing industrial scale, deepening supplier ecosystems, and relentless factory learning.[69] Battery production is highly concentrated in Asia, which produces more than three-quarters of advanced batteries. As decarbonization efforts continue and battery costs continue to come down, demand for batteries is likely to more than double by 2030 to 4.2 terawatt-hours and quadruple by 2035 to 6.8 terawatt-hours, according to analysis by McKinsey Battery Insights.

This investment case is one of ten used in the research for the McKinsey Global Institute's report, *Catalyzing competitiveness: Where businesses invest and why*. The report examines how variations in the basic economics of comparable projects influence investment decisions in different regions globally and the impact those decisions can have on the future of competitiveness and growth across the world.

Growth in battery demand has put materials, yields, and ecosystems at the center of competitiveness

A battery gigafactory is an at-scale plant that produces lithium-ion cells using a standardized manufacturing process to produce fundamental battery components such as electrodes and to assemble battery cells that go into battery packs for electric vehicles and stationary energy storage. A 50 gigawatt-hour facility, the scale analyzed here, is typically organized in three to five building blocks, 12 to 20 production lines, and three consecutive manufacturing steps: preparing coated electrodes, assembling cells, and finishing cells through aging and testing.

This analysis focuses on a specific battery chemistry, lithium iron phosphate (LFP). Due to its lower cost and great thermal stability, LFP is commonly used in low- and mid-market passenger electric vehicles (EVs), commercial EVs, and battery energy storage systems. LFP chemistries are projected to account for roughly 60 percent of battery market volume in 2035. The same tools and processes are used for other battery chemistries, for instance nickel manganese cobalt (NMC), which are commonly used in mid- and upmarket EVs. NMC and related nickel-based chemistries are projected to account for roughly 38 percent of battery market volume in 2035, with other battery chemistries making up the remainder.[70] Some gigafactories process LFP and NMC batteries at the same plant, and the conclusions here therefore broadly apply to both types of batteries.

The battery value chain begins upstream with mining and refining the required raw materials. Lithium, nickel, cobalt, manganese, iron, phosphate, aluminum, copper, and graphite are extracted and then chemically processed into battery-grade inputs. Advanced chemistry turns them into active materials for cathodes and anodes and ensures purity and consistency. Advanced petrochemical processes are applied to manufacture materials for electrolytes and separators. These are then assembled into battery cells. Scale and supplier depth matter at every stage because high volumes and expertise lower unit costs and shorten lead times.

This part of the EV supply chain today is highly concentrated in Asia, especially in China, home to most of the global capacity in lithium refining and a dominant share of LFP and NMC battery cathode materials and graphite anodes. That concentration reduces input prices, logistics, and working capital needs for Chinese battery cell makers, while regions with smaller upstream footprints often pay more for the same materials once transportation, tariffs, and compliance are included.

The downstream value chain starts once battery cells leave the factory. Cells are integrated into complete battery packs, which include cooling, housing, sensors, and a battery-management system. Historically, this was done with intermediate modules, but is now increasingly achieved with cell-to-pack and even cell-to-chassis designs that place cells directly into a pack or vehicle.[71] Most cells—up to 90 percent of global volumes through 2030—go into EVs, although a growing share goes to stationary energy storage, with packs configured into cabinets or containers for use in a power grid or at customer sites.

At this end of the chain, value comes from safe, reliable integration and from software that manages performance over a battery's life. After first use, batteries can be reused as spare parts or recycled to recover valuable materials, creating feedback loops upstream. As demand grows, every step of this downstream system is scaling, with particularly fast expansion in grid-scale battery energy storage systems related to increasing wind and solar power generation.

China is the world's largest battery manufacturing base, although Japan and South Korea are holding their own

China is home to most battery cell manufacturing and has a dense ecosystem of upstream suppliers and equipment makers, making it easier to scale large plants quickly (Exhibit 1). South Korea and Japan are also important producers, supplying global automakers through long-established relationships. Europe and North America have announced plans to expand manufacturing capacity significantly, but their installed bases are small, and many projects face execution, cost, and ramp-up headwinds compared with Asian benchmarks. Recent McKinsey Battery Insights analysis indicates that North America's maximum production capacity could rise from roughly 0.3 terawatt-hour in 2024 to more than 1.3 terawatt-hours by 2030, while Europe has announced capacity additions of several hundred gigawatt-hours. However, not all announced projects are likely to reach production, and both regions continue to need sustained public support and financing (especially for first-time developers), faster scaling, and localization of midstream supply such as LFP cathode and graphite anodes.[72]

Regional demand creates a different picture. At the global level, announced battery cell capacity appears sufficient to cover demand through 2030, and current supply exceeds demand in some parts of the market, especially in China. However, regional imbalances remain significant. China's installed and announced capacity can meet domestic needs and support substantial exports, whereas North America and Europe are expected to continue relying on imports to balance demand, particularly for LFP cells. That dependence is even greater upstream because the cathode-active material and precursors used in LFP batteries are almost entirely produced in China.[73] McKinsey Battery Insights analysis indicates that China will remain a net exporter to multiple regions beyond 2030, reflecting its cost position and surplus capacity in parts of the battery value chain.

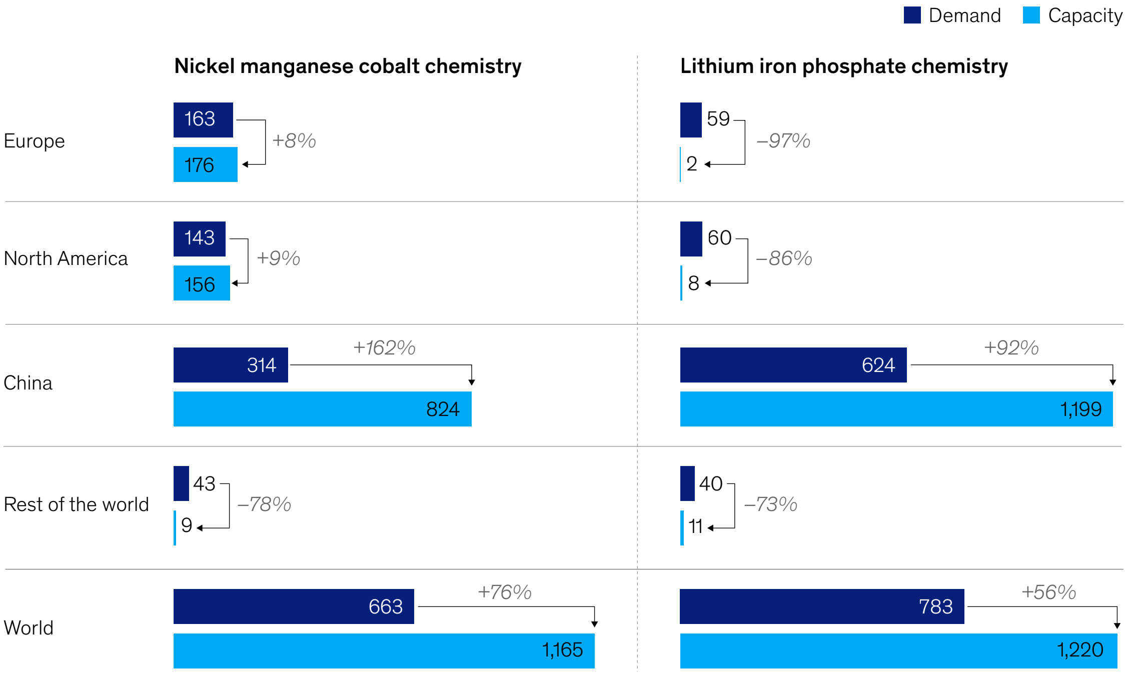
Public programs are beginning to reshape where battery capacity is built. In the United States, the Inflation Reduction Act and state-level incentives helped spur a strong pipeline of cell plants and upstream investments, although recent federal policy changes have created more uncertainty about some clean-energy and EV-related incentives. Europe has introduced support through the Green Deal Industrial Plan and national measures, complemented by local-content and rules-of-origin requirements. For example, after the United Kingdom left the European Union, the two regions signed a trade and cooperation agreement with rules of origin requiring electric vehicles and their batteries to meet minimum European- or UK-content thresholds to qualify for tariff-free trade.[74]

Additionally, the EU-27's proposed Industrial Accelerator Act embeds European-content and resilience requirements into public procurement and clean-tech support.[75] These initiatives seek to reduce import dependence, build resilience near key automotive hubs, and secure the industrial foundations of Europe's auto sector. Absent sufficient domestic battery capacity, Europe risks exposing one of its core industries to strategic dependence and long-term competitive erosion.

Exhibit 1

China has manufacturing capacity to supply all of the world's battery needs.

Li-ion cell adjusted production capacity and demand, 2025, GWh[1]



[1] Demand is based on EV production location. Solid-state batteries are excluded from demand and supply. Chemistry demand is modeled based on regional end-user preferences, technology performance, and commercial readiness.
Source: McKinsey Battery Insights; McKinsey Global Institute analysis

McKinsey & Company

China is the benchmark because scale and supply-chain depth lower battery cell costs

The modeled investment case evaluates a greenfield 50 gigawatt-hour factory for LFP batteries in four regions: China and the United States; Spain as an example of a European country with significant battery investment; and Malaysia because it exemplifies the wave of new battery-manufacturing investment in Southeast Asia (see sidebar "Methodology").[76]

The levelized cost framework used in this analysis combines the cost of building and equipping a plant, ongoing costs of running it, and region-specific business conditions. In our model, we have not specified the number of individual batteries produced. However, the average EV today has a battery with a capacity of 50 to 70 kilowatt-hours, and a 50-gigawatt factory could, ignoring potential yield loss considerations, produce 700,000 to one million such batteries a year.

China is the natural base case for costs in this industry because its battery companies participate deeply across the supply chain and already operate many plants at scale efficiently. China's presence is extensive in upstream processing of key materials for LFPs, which reduces input prices and simplifies logistics for local battery makers. The country also produces a leading share of cathode and anode materials and is strong in lithium refining, which reduces the delivered costs of materials and anchors overall cost advantages for domestic producers. Years of government support across the battery value chain have helped build the scale and supplier depth that lower China's costs today, advantages reflected in our levelized cost comparison even though it excludes direct subsidies.[77]

Sidebar

Methodology

This investment case compares the costs of a greenfield 50 gigawatt-hour factory for lithium iron phosphate batteries in various geographies to understand what makes some regions more cost competitive than others. Our levelized cost methodology converts a project's full life cycle economics into a single unit cost. It can be interpreted as the unit price that would make a project's net present value equal to zero over its entire life cycle, which is the minimum price that makes that project viable and is in line with the macroeconomic concept of long-term marginal costs. The concept is commonly applied in the energy sector, where it is known as the levelized cost of energy. We do not consider taxes, subsidies, and externalities, which vary and are hard to pin down.

The calculations are informed by McKinsey's work on the battery industry, which provides our understanding of the capital expenditures, labor, energy, materials, and other inputs, as well as time, typically needed to build and operate a gigafactory. We price these inputs at the typical costs in a geography, drawing on proprietary databases maintained by MGI's Economics Research team, and at the typical weighted average costs of capital, drawing on McKinsey's Value Intelligence Platform, a curated database of the financials of global companies.

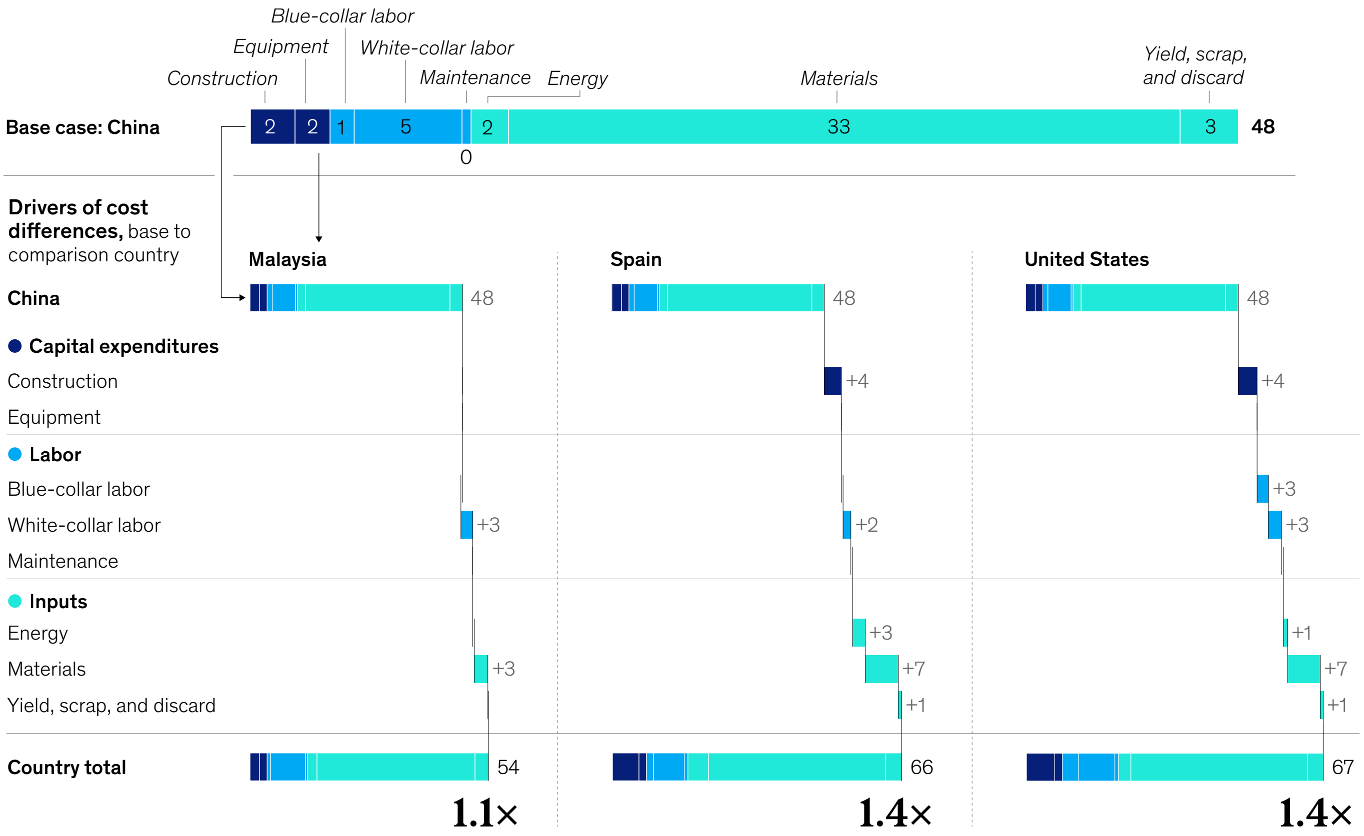
In every region, materials—anode active materials such as graphite; cathode active materials such as nickel, cobalt, manganese, and aluminum; electrolytes, separators and other components and additives—account for 60 to 70 percent of battery costs. The next-largest contributor to cost is white-collar labor, mostly in R&D and SG&A, accounting for 10 to 15 percent of total costs. Capital expenditures, which are split roughly equally between construction and equipment, represent about 10 percent of costs. Yield losses account for 5 to 8 percent of total costs. Blue-collar labor, maintenance, and energy costs make up the remainder.

China's aggregate costs are the lowest, a result of denser local supply chains, experienced producers with high yields and utilization, lower labor and energy costs, and lower installed costs of equipment and buildings. Each mechanism reduces the cost per kilowatt-hour that must be recouped through sales (Exhibit 2).

Exhibit 2

Materials and labor costs drive the economics of battery production.

Levelized cost of batteries in 2025, $/kWh, before taxes and direct subsidies



Source: McKinsey Battery Insights; McKinsey Global Institute analysis

McKinsey & Company

Cost differences across regions are largely driven by materials costs

Materials, which are the biggest expense in producing a battery and most exposed to potential glitches in supply chains, explain about 40 percent of cost differences across regions. Compared to China, a battery project in Malaysia pays about $3 more for battery materials, and European and US projects pay about $7 more per kilowatt-hour, accounting for 40 to 50 percent of the cost gap. Where production of cathode and anode materials is limited, such as LFP cathode (iron-phosphate) and graphite anode in Europe and North America, local factories typically pay more once freight, tariffs, compliance, and supplier margins are included. China's proximity to large-scale producers of these inputs reduces delivered prices and working capital needs there. Until midstream capacity is scaled in the United States and Europe, imported materials or long-haul regional sourcing will result in higher costs per kilowatt-hour.

Construction accounts for about 20 percent of the cost differences that separate European and US projects from Chinese and Malaysian projects. Part of this gap is due to construction input prices. In Europe and the United States, building materials, labor rates for installation, and specialized expertise needed in building factories are far more expensive. For example, concrete prices are three times higher in the United States than in China. Additionally, local specialized vendor networks are less dense in Europe and the United States, so factories may rely on international suppliers for installation and commissioning, adding travel time and service contracts. Construction efficiency also explains part of the difference, because the variation in construction costs separating China from Europe and the United States is larger than the difference in inputs. Slower build times add overhead, and more extensive regulations require more complex designs and more advanced materials. The problem is particularly pronounced in Europe, where lower construction efficiency explains a larger part of the gap than differences in direct costs do.

White-collar labor costs vary widely across regions due to big differences in the costs of labor, processes, and ecosystem support. Wages for engineers and other highly skilled roles are higher in Europe and the United States than in China and Malaysia, adding 10 to 15 percent to the cost. Local talent pools grow at different speeds, which raises the cost of in-house R&D and corporate functions such as finance, human resources, and legal. Beyond wages, the maturity of local supplier and service networks also matters. Regions home to dense clusters of specialized vendors and well-established field support can spread technical problem-solving across partners and resolve issues faster, reducing the internal engineering effort and overhead required to coordinate it. Another factor driving these costs is the cadence of product development, which can vary widely. Some battery ecosystems move from concept to production in roughly half the time others take, requiring less engineering per product cycle and fewer years of project overhead.

Energy accounts for roughly 5 percent of additional costs in the United States and about 15 percent in Spain, where wholesale power costs are 2.5 times higher than in China. Electricity is needed continuously for air handling, dehumidification, drying, and formation, so a few cents' difference in grid prices per kilowatt-hour translates into big savings over time. Where grid power is expensive or volatile, energy-efficient equipment and heat-recovery designs become important cost levers, because they reduce operating expenses and emissions.

Yield and scrap discard account for the remaining 5 to 10 percent of the cost difference. If early production inevitably produces some cells that don't meet specifications, the required materials, energy, and labor must be written off. Regions like China with a deeper installed base of similar factories and a more robust network of factory commissioning and ramp-up specialists typically reduce discards faster and have lower ramp-up costs. Structured ramp-up programs that codify testing, failure analysis, and supplier quality can shorten the learning period and reduce this cost penalty in new plants.

Countries and companies everywhere are seeking to address cost differences

The cost drivers outlined interact with various regional efforts to shape price. In the United States, for example, policy incentives such as the Inflation Reduction Act and import tariffs ensure that eligible, efficient local producers can earn attractive margins even if their pre-incentive costs are higher than China's. Europe's situation is different. Announced capacity is large, but the region has a bigger need for LFP imports and has more cost pressure from established Asian producers due to lower import tariffs. Although it faces a steep learning curve, the European battery industry requires fast scaling of gigafactories and rapid localization of critical midstream steps to close the cost gap with China and other Asian hubs.

Business model choices also influence where value is captured. Many automakers have formed joint ventures with cell specialists to secure volume, share the risk of building and operating new factories, and align product road maps. Such partnerships can reduce the time to market because they combine certainty of demand with a cell maker's process know-how. Building capacity is capital intensive and complex, and joint ventures help distribute cost and execution responsibility in a way that lenders and policymakers often prefer.

Despite increasing policy attention and strategic pressure to localize supply, battery investment follows economics. The underlying costs, shaped not only by the direct costs of production but also by upstream integration, scale, execution capability, and reliable output, determine where new capacity is built. This continues to favor China, which has the raw materials, processing, equipment, and commissioning know-how that underpin a structurally lower cost base and support domestic supply and large export volumes.

Execution also matters. Commissioning delays and slow yield ramp-ups quickly erode project economics, giving regions with dense networks of equipment vendors, service technicians, and experienced local teams a practical advantage.

Local battery capacity becomes more attractive when logistics, incentives, and reliability line up. Where a new battery plant is located increasingly turns on factors not captured by a simple comparison of production costs. Large customers such as automakers and grid-storage integrators value proximity and reliable delivery because batteries are heavy, customized, time-sensitive components. Shorter supply chains reduce the geopolitical risk of freight and working capital needs and enable closer engineering collaboration.

European buyers, for example, report that long supplier lead times can erase nominal price advantages, increasing the value of partners that can support installation, site acceptance testing, and ramp-up on the ground. In the United States, high import duties on Chinese batteries combined with local incentives mean buyers often prioritize domestic or allied-market supplies even when list prices are higher because eligibility and logistics certainty partially outweigh unit cost in decision making. Recent McKinsey Battery Insights analysis found that tariffs can make Chinese imports structurally uncompetitive, leaving room for local producers to price at the upper end of the landed-cost curve and reinforcing a business case for increasing nearby capacity. Europe applies only modest tariffs on imported cells, so its emerging producers compete more directly with Chinese supply and rely more heavily on grants, loans, and local-content incentives to influence where gigafactories are built.

Capital efficiency, ramp-up excellence and strategic material supply are levers to narrow the gap

Materials price differences explain the majority of the cost gap — and these are, to a large extent, outside a manufacturer's control. To succeed, companies have a few levers at their disposal, including factory design, ramp-up processes, and sourcing decisions.

First, companies can design a factory around capital efficiency. A layout that shortens travel distances, a competitive tender that tests alternative equipment designs, and value-engineered buildings can reduce the capital invested per annual gigawatt-hour and advance the break-even point.

Second, companies can focus on ramp-up excellence to ensure stable output from day one. Commissioning and deploying plans, training, and service agreements that lock in response times and spare-parts availability can cut months off the journey to stable, high-yield production. That translates directly into lower unit costs and earlier revenue generation. Experience shows that many "opex surprises" in a gigafactory's first year, such as unplanned downtime or inconsistent yields, are in fact predictable and can be mitigated with good contract design and line-readiness standards.

Third, companies can optimize their strategic sourcing. Local supply is usually more expensive than importing from the lowest-cost locations, so intelligent procurement is important to balance between efficiency and resilience. In the United States, the Inflation Reduction Act incentivizes the development of domestic sourcing. In Europe, local-content rules for key components are expected to tighten over the longer term. Where localization isn't viable economically, long-term supply contracts with strategic partners can derisk critical materials.

Policymakers shape the context in which individual projects succeed. In the United States, the priority could be maintaining clear, durable guidance about incentives and accelerating domestic upstream investment to reduce the cost of locally sourced materials. This combination would protect the emerging cost position of US battery factories and reduce exposure to global price swings.

In Europe, simplifying and accelerating permitting and improving financing for first-time developers would be important to set the stage for local investments, and support may need to extend beyond initial investment and into the early years of operation, including support for bottleneck materials such as LFP cathodes and graphite.

Closing the cost gap with China is a long-term prospect that the industry elsewhere cannot shoulder alone.

Martin Linder is a McKinsey senior partner based in the Munich office, **Jakob Fleischmann** is a McKinsey partner based in the Munich office, **Anna Kortis** is a McKinsey partner based in the Vienna office, and **Olivier Bus** is a consultant based in the Amsterdam office.

The authors of the McKinsey Global Institute report, *Catalyzing competitiveness: Where investment happens and why*, would also like to thank Yunjing Kinzel, Kunsulu Nurekeyeva, and McKinsey Battery Insights for contributing to this research.

Investment case

Colocation data centers: The infrastructure race behind AI

Data center capital expenditures are surging as AI workloads grow, yet competitiveness increasingly depends on securing advanced accelerators, reliable electricity, and fast project delivery.

by Maria Goodpaster, Piotr Pikul, Anna Kortis, and Olivier Bus

Thanks to the boom in AI, data centers have moved from the background of the digital economy to center stage. They are the physical backbone behind cloud computing, enterprise software, and generative AI and support daily digital activity by businesses and consumers. Under current adoption scenarios, global data center demand could almost triple between 2025 and 2030, from about 82 gigawatts to about 220 gigawatts.[78]

The investment case is one of ten used in the research for the McKinsey Global Institute's report, *Catalyzing competitiveness: Where businesses invest and why*. The report examines how variations in the basic economics of comparable projects influence investment decisions in different regions globally and the impact those decisions can have on the future of competitiveness and growth across the world.

AI data centers are experiencing a rapid increase in investment

Not all data centers serve the same purposes. Traditional cloud data centers support a broad mix of workloads such as storage, web services, and enterprise applications. AI data centers are built for more specialized workloads, housing large clusters of advanced chips to train and run AI models. This distinction matters because AI is now a primary driver of data center growth. From 2025 to 2030, non-AI demand could increase by 1.7 times from about 38 gigawatts to 64 gigawatts. Meanwhile AI-related demand is expected to grow 3.5 times from about 44 gigawatts to 155 gigawatts, accounting for approximately 70 percent of total data center demand.[79] This analysis focuses on AI data centers.

AI data centers require two main types of workloads, training and inference. Training involves building models by processing vast data sets over concentrated periods of very high consumption of computing power. Inference is what happens after deployment, when a model is used to answer prompts, run searches, and generate content in real time. Many of the largest and most power-intensive facilities today are largely devoted to training, but inference may grow faster as AI adoption broadens.[80] This analysis assumes that AI data centers can serve both workloads and uses a blended average of the two. Global investment in data centers excluding IT hardware may exceed $1.7 trillion cumulatively through 2030.[81]

The next wave of data center development will likely combine very large training campuses, retrofitted or expanded cloud facilities, and a broader network of inference capacity located closer to users. Facilities once operated at tens of megawatts but are now being planned for hundreds of megawatts or even gigawatts, especially in the United States and China.

The United States currently has the largest share of data center investment, followed by China

The United States accounts for a significant share of data center construction (table). Northern Virginia is currently home to one of the largest data center clusters globally, but grid constraints and longer time to power are contributing to new developments in other tier-one markets and new locations.[82] Domestic cloud providers and expanding state-backed infrastructure supports large-scale developments in China.[83] China's largest data center hubs remain concentrated in eastern and coastal regions where demand is high such as Shanghai and the Pearl River Delta, as well as in Beijing in the north. New capacity is increasingly being pushed into western regions with abundant energy such as the Yangtze River Basin and the Chengdu-Chongqing economic zone, under the "Eastern Data, Western Computing" strategy.[84]

Elsewhere, data center expansion is smaller. The United Kingdom has the most datacenters in Europe, and construction is picking up in France and the Nordic countries, which have more abundant energy. The Nordics in particular benefit from lower-cost, low-carbon power, a cooler climate requiring less energy for cooling, and room to scale. Singapore is Southeast Asia's established regional hub with a longstanding reputation for serving demand from multinational firms, even though land and power constraints have pushed incremental growth into nearby Johor, Malaysia.[85]

Table

Installed hyperscaler data center and colocation capacity in 2025 by countries analyzed

Country	Installed capacity (gigawatts, 2025)	Region examined in this analysis
United States	36.0	North Virginia
China	20	Beijing and Shanghai
United Kingdom	2.2	London
Sweden	0.8	Northern Sweden
Singapore	1.4	Singapore
Global	83.0	

Regional differences in electricity prices and cooling needs explain the difference in levelized costs

This analysis models a 100-megawatt, liquid-cooled AI data center, representing a typical phase in a larger campus build-out. It assumes a colocation model, so costs include only the physical infrastructure needed to build and operate the facility and exclude IT hardware such as graphics processing units and servers, which users who rent the space provide. This allows a like-for-like comparison of data center infrastructure economics across countries (see sidebar "Methodology").

China is the base case in this analysis and reflects the cost in large demand-center markets where demand is high, such as Shanghai. We compare it to similar data center investments in Northern Virginia, Singapore, Northern Sweden, and London.

Sidebar

Methodology

This investment case compares the costs of an AI data center project across various geographies to understand what makes some regions more cost-competitive than others. Our levelized cost methodology converts a project's full life cycle economics into a single unit cost. It can be interpreted as the unit price that would make a project's net present value equal to zero over its entire life cycle, which is the minimum price that makes that project viable and is in line with the macroeconomic concept of long run marginal costs. It is also in line with the macroeconomic concept of long-term marginal costs. The levelized cost concept is commonly applied in the energy sector, where it is known as the levelized cost of energy. We do not consider taxes, subsidies, and externalities, which vary and are hard to pin down.

The calculations are informed by McKinsey's work in the data center industry, which provides our understanding of the capital expenditure, labor, energy, materials, and other inputs, as well as time, typically needed to build and operate a data center. We price the inputs at the typical costs in a geography, drawing on proprietary databases maintained by MGI's Economics Research team, and at the typical weighted average costs of capital, drawing on McKinsey's Value Intelligence platform, a curated database of the financials of companies globally.

Benchmark: China's eastern region

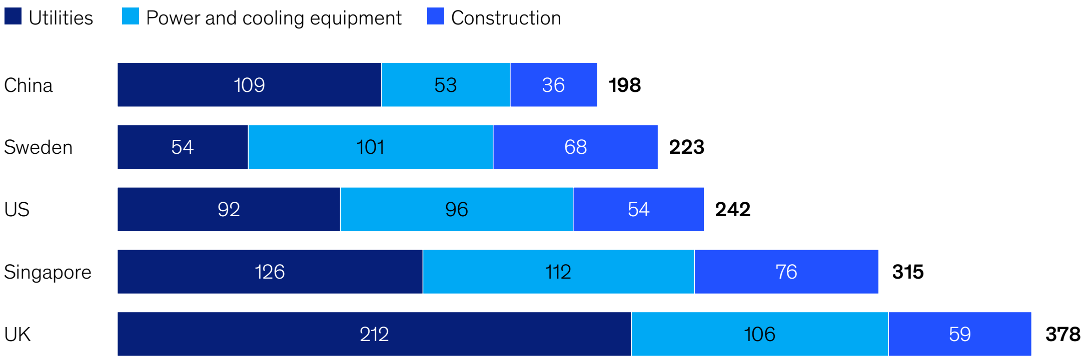
The levelized cost of data center energy, measured in dollars per megawatt-hour (MWh) of facility energy, captures the lifetime cost of building and operating physical data center infrastructure.

In the five countries in the analysis, levelized cost ranges from roughly $200 per MWh in places in China where demand is high to close to $380 per megawatt hour in London (Exhibit 1).[86] In China, costs break down as follows: 55 percent of costs relate to utilities, just under 30 percent to power and cooling equipment, and the remainder to construction.

Exhibit 1

Utility prices and capex are the biggest costs of building and operating an AI colocation data center.

Levelized cost of AI colocation data center energy, $/MWh of facility energy,[1] before taxes and direct subsidies



Note: Levelized costs shown are pretax.

[1] Reflects a 100-megawatt AI data center facility, excluding IT hardware. “Data centre construction cost trends,” Turner & Townsend, 2025; “Global construction market intelligence,” Turner & Townsend, 2025; “Asia Pacific data centre construction cost guide,” Cushman & Wakefield, 2026. A 7-percent premium was applied to the Turner & Townsend data center cost index to convert air-cooled cloud data center costs to liquid-cooled AI data center costs.

Source: McKinsey Global Institute analysis

McKinsey & Company

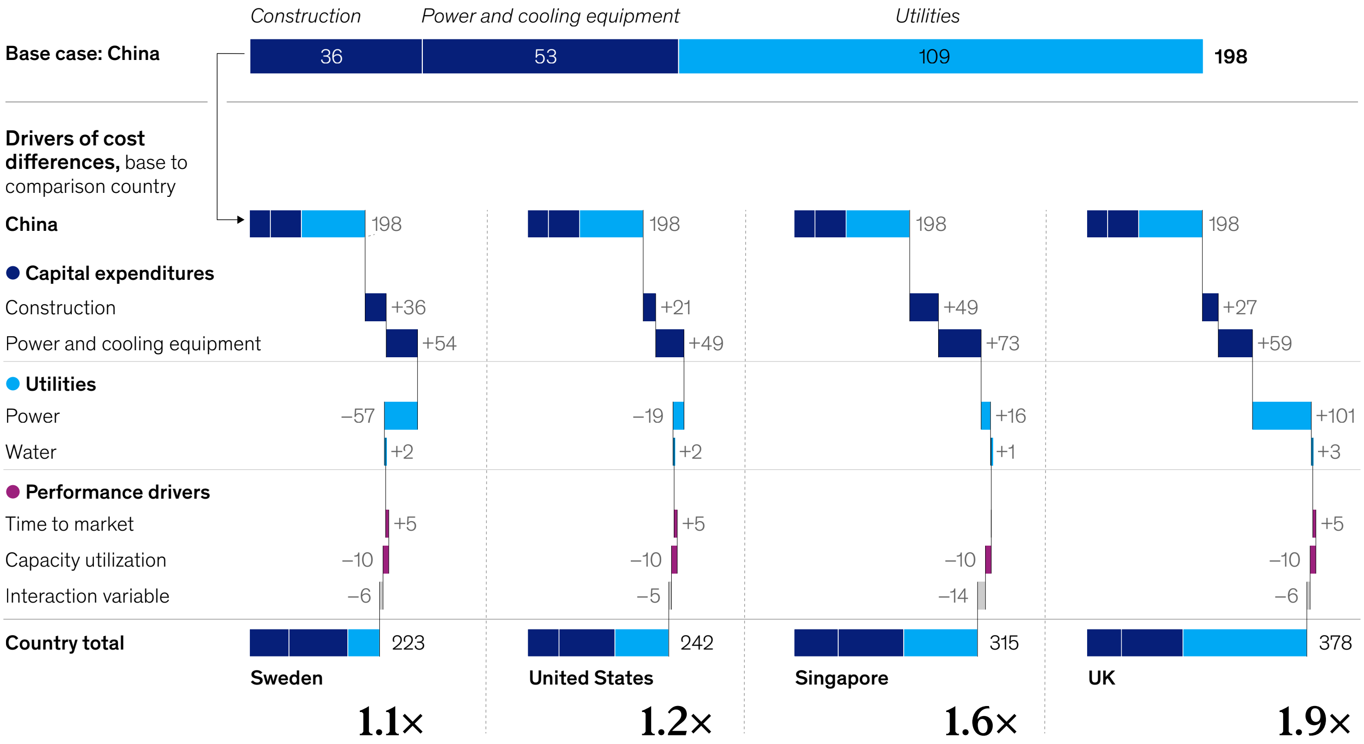
Electricity is the main reason for the cost gap. Electricity prices are 1.9 times higher in London than in China’s major demand centers in Beijing and Shanghai, explaining nearly 60 percent of the difference. Across countries, utilities account for almost 30 percent of the variation in levelized cost, making it the single most important cost driver (Exhibit 2).

Power and cooling equipment accounts for close to 30 percent of the variation. Hotter climates like Singapore require more intensive cooling. By contrast, markets like northern Sweden and the United Kingdom can have higher equipment costs because of stricter redundancy or performance requirements. China has lower power and cooling equipment costs, reflecting its large manufacturing scale.

Exhibit 2

Energy costs account for much of the variation in the cost of an AI colocation data center across countries.

Levelized cost of AI colocation data center energy, $/MWh of facility energy,[1] before taxes and direct subsidies



[1] 100-megawatt tier 3–equivalent AI data center.
Source: McKinsey Global Institute analysis

McKinsey & Company

Our analysis suggests AI data centers are found in two categories of markets, supply-advantaged expansion markets and demand-led hubs with deep digital ecosystems. They are highly power-intensive assets, so lower-cost electricity can create a major advantage for supply-oriented markets like Sweden. But they are also highly networked assets, requiring fiber connectivity and proximity to major users, which explains why more expensive markets like the United Kingdom still attract investment.

Moreover, the highest-performing leading-edge chips are subject to export controls relating to China. If less highly performing chips are used, as is generally the case in China, the energy consumption for each unit of compute increases, flipping the economics (see sidebar “Why chips flip the economics”).

Sidebar

Why chips can flip the economics

Our levelized cost analysis isolates the cost of building and operating AI data center infrastructure, which is the typical business model for colocation data center players. However, the economics for AI labs depend own infrastructure and computing hardware, which means that differences in chip or graphics processing unit availability can materially change the calculus across countries.

The United States has strong positioning in advanced AI compute due to a combination of factors such as the dominance of cutting-edge companies in AI accelerator design, close integration with leading semiconductor manufacturers in Taiwan and South Korea, and a mature software ecosystem that enables their chips to be deployed at scale. Access to the most advanced AI chips in mainland China is limited by US export controls.

These constraints have contributed to increased reliance on domestic alternatives and on building a more self-reliant semiconductor ecosystem. These approaches can still support rapid build-outs but may involve tradeoffs in performance, power efficiency, and utilization, especially for frontier AI workloads.

Chinese systems have lower compute efficiency compared to the latest platforms from leading US companies.[1] The compute efficiency of their chips, measured in PFLOPS per megawatt, is ten times or more that of China's most sophisticated chip. As a result, a larger number of Chinese chips are needed to deliver the same level of computing power. The requirement of a larger number of graphic processing units may have an impact on cost-effectiveness depending on configuration and use case.

This highlights an important dynamic: Data center infrastructure economics and GPU economics are closely linked outside China where AI labs source the same chips—but they also affect the case in China. If the available chips in China are less efficient, more hardware is needed to deliver the same output, raising levelized cost. While China may have advantages in data center infrastructure, these advantages can diminish and even disappear after differences in chips are taken into account.

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[1] This comparison is measured in petaflops, a measure of supercomputer speed that represents the ability to perform one quadrillion (10^15) floating-point calculations per second.

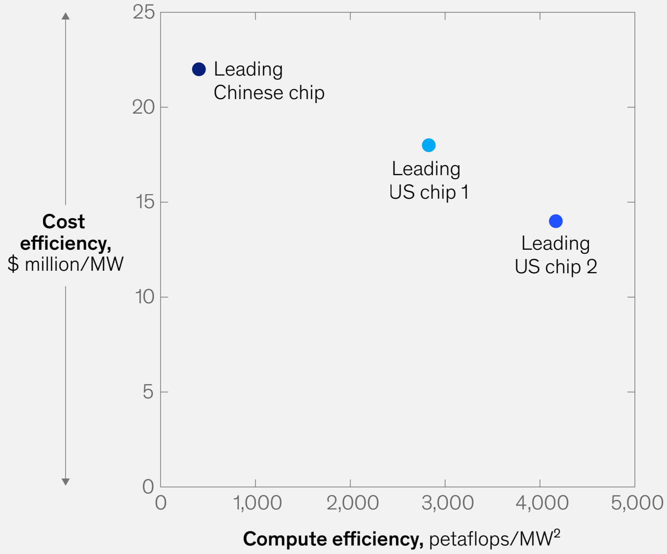
Sidebar (continued)

Why chips can flip the economics

Exhibit 3

China's current leading-edge chip lags other leading-edge chips in computing efficiency and cost.

Cost efficiency vs computing efficiency of leading-edge GPUs[1]



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[1] Graphics processing units.
[2] Petaflops (PFLOPS) are used to measure cutting-edge computing power. One PFLOP equals one quadrillion floating-point operations per second.
Source: McKinsey Global Institute analysis

McKinsey & Company

Geography matters more on the cost side, and business model matters more on the revenue side

Data center revenues are less dependent on geography than costs. Colocation pricing does vary across markets, but rental rates vary less than levelized costs and overlap substantially across major data center hubs. Pricing depends not just on location but also on customer type, contract structure, and local supply-demand balance.

Because this analysis focuses on colocation data centers, the relevant revenue benchmark is colocation pricing in dollars per kilowatt per month. Here, the biggest differences are often influenced by business model rather than by geography. Colocation data centers are owned by operators like Equinix, QTS, Digital Realty, DATA4, and ChinData that serve both large hyperscaler tenants and smaller enterprise customers.

Retail colocation, which serves smaller or more fragmented customers, typically has higher pricing because those providers offer greater flexibility, redundancy, and managed services. At the same time, large-scale deployments, whether through hyperscaler tenants or through wholesale colocation agreements for large enterprises are lower risk and lower priced because capacity is often preleased under large, long-term commitments from one or a few customers.

This difference has an impact on returns. Retail colocation typically earns about $200 to $380 per kilowatt per month and can generate equity internal rates of return of roughly 20 to 25 percent. Wholesale leases earn less, at about $150 to $200 per kilowatt per month with internal rates of return of about 13 to 18 percent.

This suggests that lower levelized cost does not automatically translate into higher returns. Business models and market saturation determine whether cost advantages translate into higher returns.

Markets attracting investment today are ones that combine connectivity, demand, and speed of execution

Beyond cost advantages, AI data center investment flows to markets that offer connectivity, speed of execution, and, increasingly, strategic alignment with national AI priorities.

Connectivity is important for AI data centers, especially those serving inference workloads, need to sit within dense fiber networks and close to major users. This explains why established hubs such as Northern Virginia, London, and Singapore continue to attract investment even when they are not the cheapest places to build or source electricity.

Investment tends to favor markets with demonstrated demand. Developers are more willing to build at scale when they have access to a base of hyperscaler, enterprise, or public-sector customers and when future utilization is supported by preleasing or expansion by existing tenants. In these cases,

Speed of execution matters as projects become larger and more complex.[87] Labor shortages, equipment lead times, permitting delays, and slow grid connections can prevent otherwise attractive markets from adding new capacity fast enough. Lead times to obtain key components such as generators, chillers, transformers, and switchgear have more than doubled since 2019, in some cases reaching more than three years. Grid connection is another bottleneck, with average wait times now exceeding four years; in some markets, connection to power can take as long as a decade.[88] Such constraints are already pushing construction costs higher and extending build times, limiting how quickly new capacity can be delivered even in otherwise advantaged markets.

Government priorities are shaping investment flows more directly than before. In Europe and elsewhere, so-called sovereign AI, or plans to develop and host AI infrastructure domestically rather than relying on foreign providers, is gaining traction. For example, SoftBank's recent pledge to invest up to €75 billion in a five-gigawatt AI infrastructure network in France underscores the role of the country's power availability, government backing, customer access, and sovereign AI priorities in attracting AI data center investment.[89]

Taken together, these factors help explain why investment does not always flow only to the cheapest energy markets only and highlight the importance of creating a market where datacenter projects are easier to deliver and scale. As much as 50 percent of global data center capacity due to come online in 2026 could be delayed by permitting, grid connection delays, public opposition, and rising power demand.[90]

Reducing the time it takes to connect a data center to power may include asking data center operators to leverage long-term power contracts or come up with self-generation arrangements, as some hyperscalers are already doing. Such steps can offset the impact of data centers on local electricity costs, which have already started to rise in Northern Virginia and other parts of the United States.[91] As projects scale up, solutions may involve going beyond permitting to create shovel-ready sites faster and support standardized designs that can gain approvals more efficiently. Improved schedules are often more valuable than improved costs and remain a top priority for data center developers.

A clear strategic approach, especially in more fragmented markets like Europe, may help policymakers. Without strategic alignment, lower-cost energy locations such as Iberia and the Nordic countries may remain underutilized while high-demand hubs such as Paris, Frankfurt, and London are constrained. The key is aligning data center ambitions with advantages in power, networks, demand, and execution.

Maria Goodpaster is a McKinsey partner based in the Dallas office, **Piotr Pikul** is a partner based in the Toronto office, **Anna Kortis** is a McKinsey partner based in the Vienna office, and **Olivier Bus** is a consultant based in the Amsterdam office.

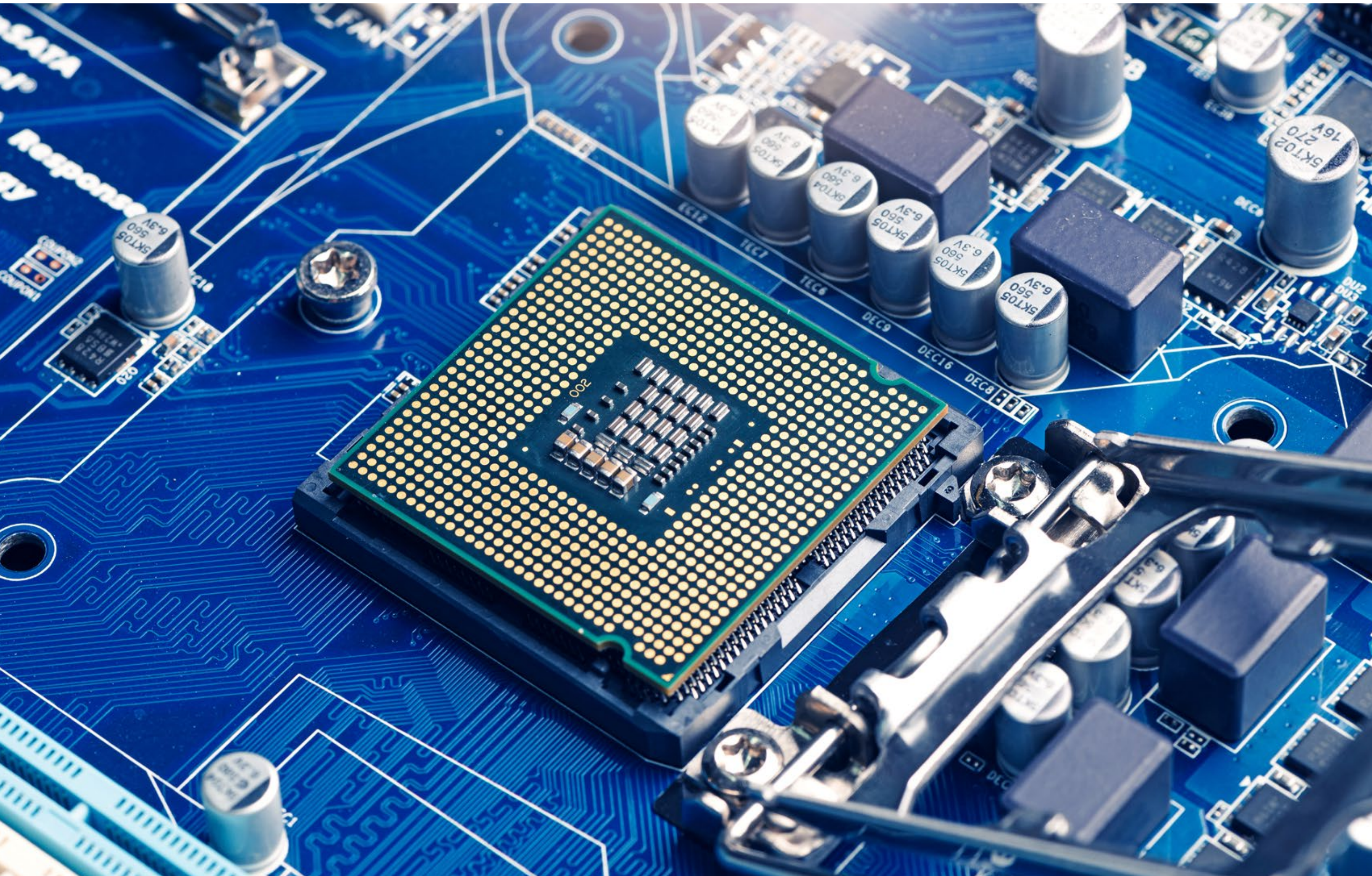
The authors of the McKinsey Global Institute report, *Catalyzing competitiveness: Where investment happens and why*, would also like to Konstantin Wirth and Shu Chern Lim for contributing to this research.

Investment case

Semiconductors: Etching the new map of strategic supply

As geopolitics shift, more countries are wooing semiconductor manufacturers to enhance resilience. At the same time, demand for advanced semiconductors continues to grow.

by Marc de Jong, Johan Rauer, Anna Kortis, Olivier Bus, and Stefan Burghardt



Semiconductor chips are the foundation beneath a range of technologies, and semiconductor manufacturing has become a strategically contested industry as governments race to secure technological leadership, supply-chain resilience, and national security. Roughly $1 trillion in investments are expected to go into chips through 2030. Semiconductors are produced in highly specialized plants called "fabs," where billions of dollars are committed long before revenues begin to flow. Although equipment and materials account for much of a fab's cost, they differ relatively little across regions. The real cost gap lies in labor productivity, construction costs, energy costs, and the speed with which projects move from plans to fabs and from steel in the ground to high-volume production. This means the ability to combine capital with productive labor and fast execution can determine where value is captured in the next era of chip manufacturing.

This investment case is one of ten that are the foundation of the McKinsey Global Institute's report, *Catalyzing competitiveness: Where investment happens and why*. The report examines how variations in the basic economics of comparable projects influence investment decisions in different regions globally and the impact those decisions can have on the future of competitiveness and growth across the world.

A trillion dollars of additional investment is moving into one of the world's most complex manufacturing systems

The global semiconductor industry is expected to generate more than $1.6 trillion in annual revenues by 2030, with about $1.0 trillion in planned investment expected.[92] Industry demand is led by the boom in AI datacenters, as well as by continued growth across computing, wireless, industrial, and automotive applications.

Semiconductor fabs typically specialize by the resolution of patterns, for example, process node and density range, imprinted onto a silicon wafer. These patterns are specified in nanometers, or one-billionth of a meter. The sophistication of semiconductors is continuously evolving. So-called leading-edge semiconductors like those used in smartphones or to train AI models are made with tiny node sizes of three to two nanometers and smaller. These chips are highly complex and currently manufactured by only three companies globally. Advanced semiconductors, with typical node sizes between 22 and 65 nanometers, are global workhorses in many electronics, automotive, and industrial applications and are expected to remain a significant part of installed capacity over the medium term. More manufacturers produce these chips, which are less technically demanding, more established, and supported by a deeper global pool of equipment, process expertise, and operating experience. Finally, mature semiconductors employ node sizes of 90 nanometers and above and are used for simpler, lower-cost functions that don't require computing density, for example, basic chips that control home appliances and motor drivers in industrial equipment. They are typically produced in older fabs.

A modern leading-edge or advanced semiconductor fab produces 300-millimeter wafers—thin circular slices of silicon—via hundreds of tightly controlled steps. The chips go through repeat cycles of lithography, deposition of thin films, ion implanting, heating, etching to remove material, cleaning, and chemical and mechanical polishing to create flat surfaces. After fabrication, wafers are tested, cut into individual chips, packaged, and quality checked before being shipped to electronics manufacturers. These final steps, called back-end, are often performed by specialized assembly and testing businesses known as outsourced semiconductor assembly and test companies, or OSATs.

Chip production is centered in Asia even as policy pushes capacity closer to demand
Installed manufacturing capacity for logic chips is concentrated in Asia. This is most pronounced in leading-edge chips, with TSMC and Samsung operating the only foundries that produce them at scale. In advanced nodes, Taiwan and South Korea are the major producers in Asia, while Mainland China has built substantial capacity and is expanding quickly. However, capacity to produce mature nodes has increased most in Mainland China and now exceeds the installed capacity of Taiwan and South Korea to produce those larger-node logic chips. Japan and Singapore also have significant capacity to produce advanced and mature nodes.

The United States and Europe are in a different position. While they have important capabilities and significant production, they rely heavily on imports for leading-edge chips and continue to import a substantial share of advanced-node logic chips.

Across major economies, policy goals start from different points. China's industrial policy aims to raise self-sufficiency by increasing domestic production of advanced and mature nodes, especially for domestic markets. The United States and Europe are more intent on reducing import reliance, improving supply-chain resilience, and supporting strategically important capacity for existing industries and technology priorities. Fab proximity is especially useful in the automotive and industrial sectors, which suffered from a chip shortage from 2020 to 2023.[93] Despite these differences, a common policy pattern is clear: Governments are pairing capital support with legislation and other measures to strengthen local fab ecosystems.[94]

Taiwan anchors the cost comparison as the leading producer of advanced semiconductors

Our base case is a fab that produces 28-nanometer logic chips with a capacity of 400,000 wafers per year. Taiwan is the base-case location because it is by far the world's top producer of advanced semiconductors.[95] We benchmark it against similarly sized factories using the same technology in Mainland China, the United States, and Germany, Europe's largest semiconductor manufacturing hub by chip capacity.

In the base case, materials like wafers and consumables, including photoresists, specialty gases, targets, and slurries, account for 25 percent of the levelized cost, a measure of the average cost of production over the lifetime of a project. Equipment such as the lithography, deposition, etching, metrology, and related tools needed to run a production line accounts for roughly 35 percent. Utilities and construction account for 10 to 15 percent of the levelized cost each, and maintenance and labor make up the rest of the total (see sidebar "Methodology").

Taiwan anchors the global comparison operationally, too. The country's fabs combine efficient execution with supplier proximity and a long track record of manufacturing discipline, which translates into competitive unit costs on a "pure operations" basis. Many leading fabs are headquartered there, and the presence of OSATs and materials suppliers supports speed and resilience.

Exhibit 1

Taiwan accounts for most of the production of advanced semiconductors.

Levelized cost of advanced semiconductors,[1] $/wafer, before taxes and direct subsidies

Note: Numbers may not sum precisely due to rounding.
[1] We use a 28-nanometer node size in a 400,000 wafer starts per year fabrication plant for comparison.
Source: McKinsey Global Institute analysis

McKinsey & Company

Sidebar

Methodology

This investment case compares the costs of advanced semiconductor fab across various geographies to understand what makes some regions more cost-competitive than others. Our levelized cost methodology converts a project's full life cycle economics into a single unit cost. It can be interpreted as the unit price that would make a project's net present value equal to zero over its entire life cycle, which is the minimum price that makes that project viable and is in line with the macroeconomic concept of long run marginal costs. The levelized cost concept is commonly applied in the energy sector, where it is known as the levelized cost of energy. We do not consider taxes, subsidies, and externalities, which vary and are hard to pin down.

The calculations are informed by McKinsey's work in the semiconductor industry, which provides our understanding of the capital expenditure, labor, energy, materials, and other inputs, as well as time, typically needed to build and operate a semiconductor fab. We price the inputs at the typical costs in a geography, drawing on proprietary databases maintained by MGI's Economics Research team, and at the typical weighted average costs of capital, drawing on McKinsey's Value Intelligence platform, a curated database of the financials of companies globally.

Higher wages and slower construction raise the cost of fabs in Europe and the United States

Labor is the most significant cost differentiator operationally, particularly when comparing Asia to Europe and the United States. Labor costs account for less than 10 percent of costs in the base case but explain more than 35 percent of the difference between Taiwan and Germany and about 50 percent of the difference between Taiwan and the United States. Roughly three quarters of the difference in labor costs between Taiwan and the United States is due to higher American wages. About 20 percent of that gap is related to greater Taiwanese hourly productivity and the remaining 5 percent to Taiwanese employees working more hours. Comparing Germany and Taiwan, 60 percent of the gap is explained by higher wages in Germany, and 30 percent is due to higher Taiwanese productivity and 10 percent to more hours of work per employee there. Although salaries are slightly lower in Mainland China, workers in Taiwan are roughly 30 percent more productive per hour, making labor there more cost competitive.

Labor productivity in fabs reflects the labor intensity required to sustain stable, high-throughput operations. This includes the number of operators needed to run the line, the consistency of production flow across shifts, and the effectiveness of maintenance and engineering teams in keeping critical equipment available. Regions with deep pools of experienced operators, technicians, and equipment engineers can sustain higher effective utilization with lower labor intensity, reducing unit costs. Advanced semiconductor clusters also benefit from talent circulation in fabs, equipment suppliers, and materials providers, which helps spread operational know-how and best practices. This difference in labor costs likely also explains part of the difference in maintenance costs among regions.

Construction costs are the second-largest driver of differences in levelized cost across geographies, explaining 30 to 40 percent of the difference between Asia and Europe and the United States. Excluding equipment, the construction cost of building a plant that produces 400,000 wafers a year is at least twice as much in Europe and the United States as in Taiwan. Excluding permitting and design time, fabs in Mainland China and Taiwan usually start initial production 12 to 16 months after construction begins, but European and US projects typically start production after 24 months. Productivity per construction worker in Asia is higher, largely due to longer work hours in Asia and more stringent regulation in Europe and the United States, which can force projects to adopt costlier designs that take longer to build. Permitting adds a few months but is a less significant cost driver because the fab construction process is highly modular and permitting can occur in parallel with construction.

Energy and utilities are the third-largest driver of differences in levelized costs, with a particular impact in Germany. Average industrial energy prices are 30 percent greater in Germany than in Taiwan, and utilities account for about 10 percent of the cost difference between the two countries. To be sure, energy prices can vary widely from project to project, and certain rebates or long-term power purchasing agreements with more attractive prices may give rise to project-dependent differences. Bringing German utility prices down to the level of Taiwan's would be equivalent to reducing German labor costs by about 15 percent. Power prices in Mainland China and the United States exclusive of any subsidized price agreements are lower by 20 percent and 40 percent, respectively, than they are in Taiwan. Similarly, without its energy advantage, the United States' levelized cost gap with Taiwan would be 15 percent bigger.

Equipment and input materials, although a substantial share of total costs, are similarly priced across regions and contribute little to relative differences in the costs of producing semiconductors. Specialty equipment for lithography, etching, deposition, and thermal processing, as well as specialty gases, slurries, photoresists, and wafers, are supplied by a relatively small set of global vendors. While logistics and tariffs matter, base prices and the cost of contract structures are comparable across major hubs.

Explicit incentives and taxes play an important role in cost differences around the world, offsetting higher construction costs in Europe and the United States. Such incentives are hard to quantify with precision because they are project specific. Even within a country, subsidies can vary by an order of magnitude. In Europe, subsidies are typically granted as a lump sum from national governments with approval from the EU-27, whereas the United States grants them through a mixture of federal CHIPS and Science Act funding, investment tax credits, and other tax credits. China's incentive programs target production of mature and advanced nodes, reportedly offering significant though opaque subsidies in the form of large tax rebates, lower interest rates, and subsidized land-use rights, as well as power price rebates of up to 50 percent for customers that buy Chinese chips.[96]

Such incentives materially improve the economics of adding domestic capacity and are beyond this analysis. For example, Germany's support for the recent European Semiconductor Manufacturing Company, a package that amounts to roughly half of the project's announced investment, could meaningfully narrow the gap.[97] In our model, applying similar support to capex and ramp-up costs lowers the levelized cost of a wafer from about $4,000 to $3,000, bringing it close to the Taiwan base case.[98] While many subsidies are hard to pin down and project-specific, the most effective measures are transparent subsidies per wafer that can accelerate revenue generation.

Market access and buyer preferences can change the returns on chip production

Semiconductors are easily tradable, but selling prices differ based on buyer preferences and policy controls. Notably, the price for advanced semiconductors in Mainland China is reportedly 25 to 30 percent lower than the price of identical chips made in Taiwan, Europe and the United States. This seems to be the result of a three-way dynamic. First, Chinese government support and subsidies have encouraged multiple Chinese companies to expand capacity, increasing competition in the domestic market. That added competition has pushed suppliers to price aggressively to win domestic market share, reducing profitability. Finally, customer qualification requirements, export controls, and geopolitical risk may limit demand from some international buyers, increasing pressure to sell chips domestically.

Costs matter, but resilience, proximity, and policy are playing an increasing role in investments

Comparing levelized costs with investment projections indicates that cost competitiveness plays a critical role in investment decisions. Currently, Mainland China, South Korea, and Taiwan are home to 60 percent or more of global capacity in all node sizes and are expected to attract more than 55 percent of global semiconductor capital expenditures through 2029.[99]

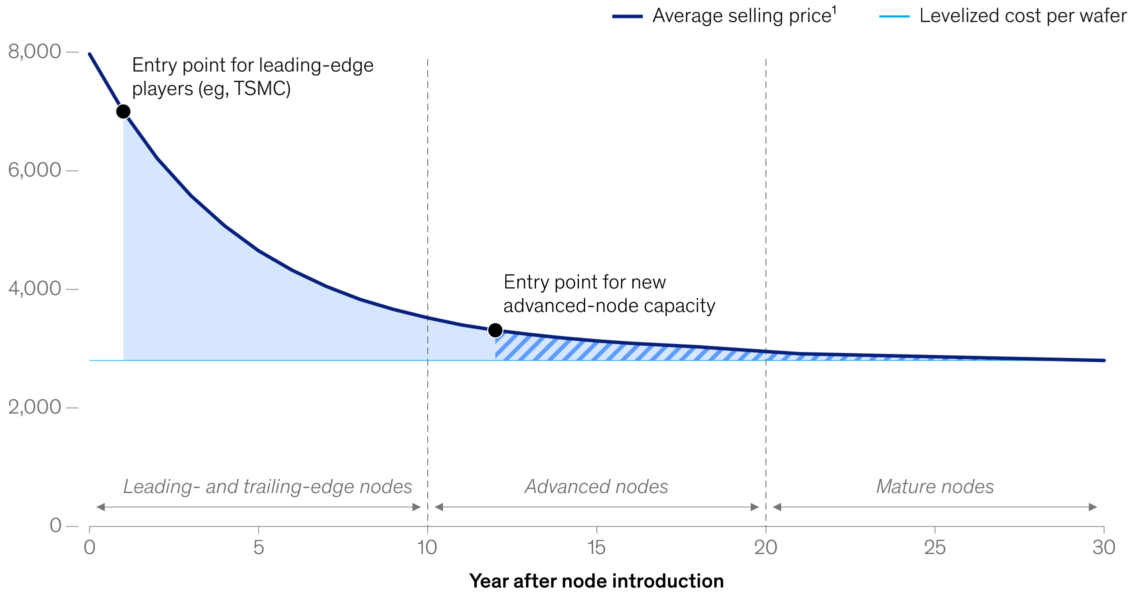
Leading producers in Taiwan and South Korea typically add capacity when a node is still at or near the technological frontier. These chips define the state of the art and command the highest prices from customers that need the best performance. As the technological frontier shifts to smaller nodes, these fabs can keep producing the same node sizes, which are no longer considered leading edge. By entering the market when these chips were leading edge, Asian producers benefit from early premium pricing, years of yield improvement, higher utilization, and lower depreciation over time compared to new fabs entering the market today at an advanced node size.

Regions building capacity today to produce advanced nodes are thus at a disadvantage. A new 28-nanometer fab in Europe or the United States entering the market after leading Asian producers have already captured much of the early profit pool and operate older, better-utilized,

Exhibit 2

Building an advanced-node fab today means production starts after the best economics have passed.

Average selling price over node lifetime,[1] $ per wafer



[1]Stylized estimate based on average observed data in deep ultraviolet nodes: 16, 28, 45, and 65 nanometers.
Source: McKinsey Global Institute analysis

McKinsey & Company

and, in some cases, already mostly depreciated fabs. Slower construction compounds that problem by pushing revenue further into a node's maturity curve.

However, cost competitiveness is not the only factor determining where investments are made. Considerations unrelated to price or economics increasingly point to where capital for fabs will flow. Automotive and industrial customers often value local supply and shorter supply chains, which supports investments in Europe and the United States even when operating costs are higher than in Asia. Minimum-distance considerations also matter for time-sensitive products and for multisourcing strategies in complex supply chains.

Investment growth is expected to average 6 percent globally through 2029, which is less than the 12 percent projected for the Americas and the 7 percent forecast for the Middle East and Africa. The Americas are projected to overtake China and become the largest destination for semiconductor capital expenditures in 2029, based on considerations including supply chain resilience and public policy that are increasingly shaping where new capacity is built.[100]

Overall rising demand and the long lifecycles of advanced-node chips, particularly in geographies that pair strong ecosystems with supplier specialization and qualified labor, make investment cases for advanced chip fabs attractive.

Corporate and policy actions supporting innovation leadership, speed, ecosystems, and demand can improve the investment case

Policy choices will determine how quickly fab plans translate into shovels in the ground. Across China, the EU-27, Japan, South Korea and the United States, support programs pair capital grants with tax credits and workforce development. In practice, the most effective packages align three elements. The first is speed and predictability, enabled by clear regulation and permitting processes that support fast construction and rapid production ramp-up, reducing schedule risk. The second element is ecosystem coinvestment, which emphasizes proximity to suppliers of equipment services, specialty gases, chemicals, OSATs and spare parts. This shortens ramp-up time and reduces downtime. The third is demand visibility. Long-term customer commitments reduce market risk and improve the business case for advanced-node projects. Such visibility is a key barrier for some projects in Europe. Where speed, ecosystem depth, and demand visibility align, projects are more likely to progress, even when their unit costs are higher than those in the most efficient Asian locations.

These levers can improve fab economics but do not change the broader logic of the node lifecycle. Producers that build at the current leading edge capture more of a node's economic profit, which decreases as a node matures. Later entrants building advanced-node capacity now compete against incumbents that have already captured the early profits and now benefit from years of yield improvement, higher utilization, and lower depreciation. Building advanced-node capacity may still be attractive when resilience, customer proximity, and strategic supply are sufficiently important. But regions seeking a stronger position in semiconductor manufacturing could also aim to participate closer to the leading edge, where more of the industry's economic profit is created.

Marc de Jong is a McKinsey senior partner based in the Amsterdam office, **Johan Rauer** is a McKinsey partner based in the Munich office, **Anna Kortis** is a McKinsey partner based in the Vienna office, **Olivier Bus** is a consultant based in the Amsterdam office, and **Stefan Burghardt** is a knowledge expert based in the Munich office.

Investment case

Biopharma R&D: The evolving formula for discovery and development

Innovation after innovation is advancing the biopharmaceutical industry, enabling better treatment of complex diseases. The industry has historically made its home in Europe and the United States, but that's changing.

by Gaurav Agrawal, Fangning Zhang, Anna Kortis, and Olivier Bus

GLP-1 therapies have triggered a boom in biopharma, the shorthand name for the slice of the pharmaceuticals business producing innovative therapies based on cells and biological processes to address complex diseases. Europe and the United States have long dominated the industry thanks to deep innovation ecosystems based on scientific discoveries, venture capital, clinical development and commercialization. In recent years, China has become a major source of pipeline assets, licensing activity, and early clinical momentum. By 2025, China accounted for about 30 percent of the global biopharma pipeline, up from 2 percent just ten years earlier, and about one-fifth of global licensing deals, according to McKinsey research. This momentum suggests China has developed capabilities that could reshape what is sometimes referred to as the 'ten-year, 10 percent success rate' model[101], establishing a new competitive frontier in biopharma increasingly defined as much by the productivity of the R&D system as by the originality of science itself.

This investment case is one of ten that are the foundation of the McKinsey Global Institute's report, *Catalyzing competitiveness: Where investment happens and why*. The report examines how investment propels competitiveness, and vice versa by analyzing the variation in costs across industries in regions around the world.

Creating value in biopharma R&D depends on how productively companies move assets through discovery and development

Biopharma R&D translates scientific hypotheses into therapeutic assets. The process typically moves through target identification, hit or lead generation, candidate selection, preclinical and studies that can lead to investigational new drugs, development through Phases I to III of clinical trials, regulatory review, and launch.[102] At each stage, companies invest to reduce technical, clinical, and regulatory uncertainty before committing larger amounts of capital in the next stage.

The biopharma industry is defined by long development timelines, uncertainty, and large up-front investment before commercial success. These dynamics are driven by the need to rigorously prove that therapies are safe and effective, obtain regulatory approval, and ensure reimbursement from health insurers or government health systems. Returns depend on successful therapies earning back not only their own costs but also the cost of failed therapies, typically over a limited period of patent and regulatory exclusivity. Economics are shaped by scientific success and by how quickly and efficiently companies move assets through key milestones, end weak programs, and concentrate resources behind the most promising opportunities.

Different R&D models exist. "Innovators" pursue first-in-class biology or new mechanisms and compete primarily on scientific differentiation. "Fast followers" become active once a target or mechanism has been clinically validated by others and so compete more on speed, development execution, and product profile. The fast follower model has a higher success rate because it follows a proven pathway. However, because fast followers enter the pathway later, their effective exclusivity is often shorter, making efficient development especially important.

Biopharma also relies on ecosystems. Most companies do not execute every step themselves. They retain control of the therapy they've developed, its IP, program leadership, and key capital-allocation decisions but outsource discovery support, preclinical work, trial operations, data management. Smaller biopharma companies may rely heavily on external partners, while larger companies typically use them more selectively. Competitive advantage therefore depends not only on internal scientific capability but also on how effectively companies orchestrate external partners.

The United States and Europe remain major biopharma hubs, but China has quickly expanded its role in global innovation

Global biopharma R&D is concentrated in a relatively small number of hubs. Clusters matter in this industry because innovation tends to concentrate in places with a tight web of top academic science, venture funding, experienced talent, clinical networks, specialist service providers, and large pharmaceutical partners.

The United States has the deepest biopharma ecosystems centered on Boston, the San Francisco Bay Area, and San Diego, which are home to original science, biotech formation, translational research, and access to capital.

The biopharma industry is more fragmented in Europe, although the continent has several important hubs including the Golden Triangle in the United Kingdom, Basel, Belgium, and parts of Germany. These clusters combine strong academic research, established pharmaceutical companies, specialist biotech ecosystems, and development capability.

China’s hub system has developed quickly over the past decade. Its biopharma companies, anchored in hubs in Beijing, Shanghai, and Suzhou, today account for about 30 percent of the global innovation pipeline.[1] That growth reflects stronger science as well as the build-out of much more complete innovation ecosystems spanning talent, capacity in contract research organizations (CROs) and contract development and manufacturing organizations (CDMOs), clinical sites, and development infrastructure.

Biopharma also becomes more global as therapies move through development. Discovery and early development are concentrated in a few hubs, but later-stage trials increasingly require approval in multiple markets. Even so, local ecosystem strength continues to shape where biopharma assets are created, how quickly they move, and where competitive advantage accumulates.

Faster development and stronger ecosystem economics materially lower biopharma R&D costs

This analysis examines the economics of biopharma R&D through the lens of levelized cost per drug developed. It compares a Chinese biopharma business and a global one, examining the difference in the cost of bringing a similar drug through discovery and development. The company is a fast-follower developing a drug using monoclonal antibodies, which are lab-made proteins designed to recognize and bind to a single specific target in the body, usually a protein on a cell surface or circulating in the blood. The company operates a full prelaunch R&D pathway spanning discovery and development. A Chinese biopharma company serves as the base case, reflecting best-in-class performance.

The case models both the discovery and development phases. Discovery encompasses all the scientific work needed to identify a target, design and optimize a lead molecule, test it in preclinical settings, and assemble the evidence required to begin human studies. Development is the clinical-trial part of biopharma R&D, spanning Phase I, Phase II, and Phase II clinical studies and the regulatory review needed for approval. The model is risk-weighted, meaning it accounts for the average success rates of a drug progressing to the next stage. Success rates are assumed to be identical for Chinese and global companies.

Both companies are assumed to be developing a drug for global launch. The Chinese player is assumed to conduct the discovery phases entirely in China. In development, Phase 1 is conducted entirely in China, Phase 2 is split 30 percent in China and 70 percent globally, and Phase 3 is conducted entirely globally to support a global launch. In contrast, the global company is assumed to have a primarily US and EU footprint and to run fully global trials. We assume a fixed commercial window due to patents and competition. Development speed affects economics in two ways. A slower development path increases R&D costs and brings launch closer to the end of the commercial window, leaving fewer years of sales over which those costs can be recovered. In the base case, annual demand is held constant, so the commercial impact of slower development is captured in fewer years of sales remaining.

The analysis isolates R&D economics only. It excludes downstream commercial infrastructure, large-scale manufacturing build-out, and other costs outside the development process, while holding demand-side assumptions constant across comparisons. Differences between the Chinese base case and similar businesses in different locations are captured through labor economics, development timelines, external ecosystems, overhead and material inputs.

China has achieved a meaningful increase in speed and reduced levelized cost of biopharma R&D

In China, the R&D timeline spans roughly 36 months of discovery work through an investigative new drug study followed by 87 months of development, implying a total time to launch of about 123 months, or just over ten years.

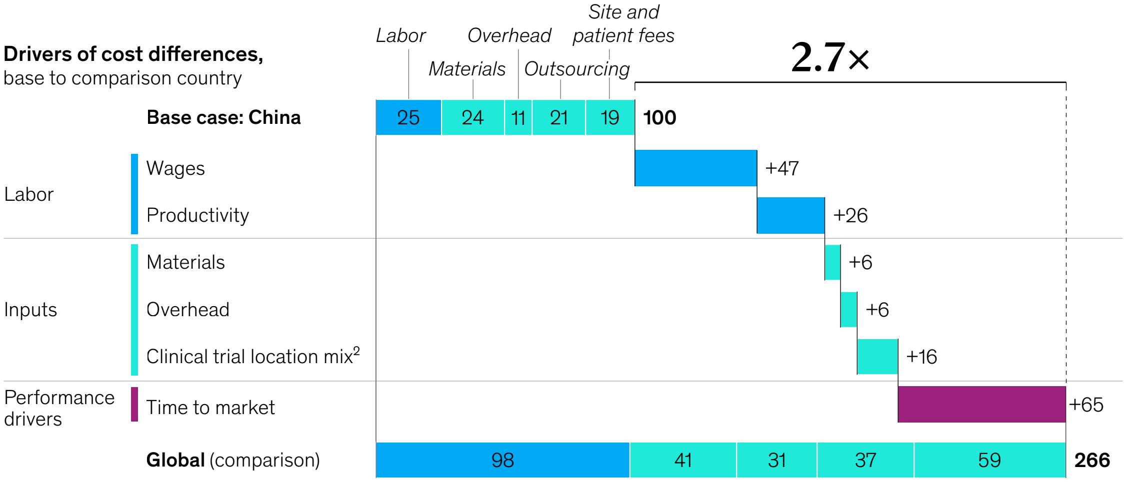
Internal labor in the base case accounts for about 25 percent of the total levelized cost, which is spent on internal scientific, clinical, regulatory, and program-management teams that lead target assessment, molecule selection, translational planning, clinical oversight, and key decisions that stay in-house. Materials such as reflecting assays, study consumables, preclinical and clinical inputs, and other nonlabor items that move a therapy forward contribute roughly 25 percent of the levelized cost. Outsourcing adds another 20 percent and includes the use of CROs and other external partners for activities such as assays, toxicology, work that enables investigative new drug studies, site start-up, monitoring, data management, and day-to-day study operations. Site and patient fees account for 20 percent, highlighting the importance of clinical execution at the site level, and overhead such as broad infrastructure, logistics, coordination and other program support contributes about 10 percent (see sidebar, Methodology).

The China base case overall illustrates the costs associated with an ecosystem-driven R&D model. Internal teams are important, but most of costs are incurred beyond in-house staffing, linked instead to materials, external partners, site activity, and supporting infrastructure.

Exhibit

Time to market accounts for most of the cost difference in biopharmaceutical R&D.

Levelized cost of discovery and development R&D,[1] indexed to 100 for base case, before taxes and direct subsidies



[1] We are considering a fast-follower strategy for developing a monoclonal antibody therapy.
[2] Includes site fees, patient fees, and outsourcing costs that depend on a chosen geography for the trials (applicable to Phase I and partially to Phase II only).
Source: McKinsey Global Institute analysis

McKinsey & Company

Sidebar

Methodology

This investment case compares the costs of a biopharmaceutical R&D project across various geographies to understand what makes some regions more cost-competitive than others. Our levelized cost methodology converts a project's full life cycle economics into a single unit cost. It can be interpreted as the unit price that would make a project's net present value equal to zero over its entire life cycle, which is the minimum price that makes that project viable and is in line with the macroeconomic concept of long-run marginal costs. The levelized cost concept is commonly applied in the energy sector, where it is known as the levelized cost of energy. We do not consider taxes, subsidies, and externalities, which vary and are hard to pin down.

The calculations are informed by McKinsey's work in the life sciences industry, which provides our understanding of the capital expenditure, labor, energy, materials, and other inputs, as well as time, typically needed to build and operate a biopharmaceutical R&D project. We price the inputs at the typical costs in a geography, drawing on proprietary databases maintained by MGI's Economics Research team, and at the typical weighted average costs of capital, drawing on McKinsey's Value Intelligence platform, a curated database of the financials of companies globally.

China's performance is driven by faster execution, lower wages, and higher productivity

Developing a successful biopharma therapy costs a multinational company about 2.7 times more compared to a Chinese company on a levelized cost basis, reflecting both higher development costs and a reduced commercial window from a longer time to market. Differences in speed, labor economics, R&D productivity, and clinical trial locations account for most of this gap.

Time to market is the top driver of China's advantage, accounting for roughly 40 percent of the cost difference. Discovery takes about 36 months in China versus 54 months globally, while development takes about 87 months compared to 100 months. China accomplishes this speed through a combination of factors explored in detail below, some of which could be replicated elsewhere. If global companies were to leverage China's speed, they would be able to launch as much as 2.5 years earlier, extending the therapy life cycle and total commercial value of the asset.

Wages account for about 25 percent of the gap. Salary levels in the discovery part of the business are roughly 50 percent lower in China across the talent pyramid. Such a difference is significant even for the fast-follower archetype, because target assessment, molecule optimization, translational planning, and program leadership still require substantial internal scientific effort.

Productivity contributes 15 percent to the gap that separates China from Europe and the United States. Chinese companies employ an operating model that incorporates a fast-to-signal approach, which uses leaner data packages and parallel processing of research steps. Workers in China's biopharma labs work longer hours than their counterparts in Europe and the United States, meaning that similar-sized teams can move faster through the discovery phase in particular.

Clinical trial location accounts for about 10 percent of the gap. Running trials is materially cheaper in China where the cost per patient in a Phase I clinical trial is about one-third of the global benchmark. Site fees, patient recruitment, monitoring, local salaries and broader study operations all contribute to that difference. Patient enrollment is two to five times faster in China, driven by an abundant patient pool with high unmet medical needs, a large population unfamiliar with treatment opportunities, and patients often highly concentrated in leading hospitals.1 Additionally, salaries in CROs and CDMOs in China are about 62 percent lower than global benchmarks, further contributing to the lower cost of running trials in China. These clinical trial advantages are bigger in early stages because later phases are increasingly global in order to secure regulatory approval for a global launch. Because programs can fail at every phase, accounting for success rates means the economics of the earlier phases matter more than costs alone would suggest.

Overhead, materials, and country risk account for the rest of the gap, contributing 1 to 3 percent each. Overhead is a relatively small contributor, and prices for input materials are also relatively consistent across geographies. The assumed weighted average cost of capital in China is slightly higher than for a global company but not enough to have a material impact on the levelized cost.

In summary, China's levelized cost advantage is explained by a combination of faster time to market, lower wages, higher productivity, lower trial costs, and a more cost-efficient external ecosystem. The difference is not the result of any one advantage but of several reinforcing ones spanning the R&D pathway. China's advantage is strongest in discovery and Phase 1, which are the most repeated stages on a biopharma pathway and the stages with the highest attrition, giving them more weight in the process. Lower cost and faster progression at those stages allow more programs to advance, increasing the number of "shots on goal" and the likelihood of success.

Delivery-focused ways of working, scaled infrastructure, and a supportive operating environment provide advantages

China's speed and cost advantage in biopharma R&D is related to six reinforcing factors that allow companies there to move 1.5 times faster from target identification to the start of clinical trials and enroll patients two to five times faster compared to the global benchmark.

The first factor is regulatory reform. China has steadily shortened clinical timelines and made the path from discovery into development more predictable through reforms. Recent measures include support for investigator-led trials, faster review of clinical trial applications, 30-day clinical trial review, and new rules for clinical research and the translation of biomedical technologies. These changes reduce friction early in development and help programs move toward patient trials more quickly.

China also has a large patient pool with high unmet need, often concentrated in large leading hospitals. It also has more than 1,500 clinical sites, more than one-fifth of which can conduct Phase 1 trials. Integrated capabilities such as imaging and biomarker testing support efficient trial execution, and the scale and concentration of the site network accelerate patient enrollment and reduce friction once a trial program starts.

Third, China has a deep and scaled network of specialist service providers that provides a one-stop-shopping model for research, development, and manufacturing. These CRO and CDMO ecosystems are more of a plug-and-play environment, where full-time employees are readily available and proximity enables fast collaboration.

In discovery, Chinese companies increasingly use a fast-to-signal approach that relies on leaner data packages, a focus on the critical path, parallel processing of early work, and iterative experimentation to generate signals quickly and derisk decisions. Senior leaders stay close to the work, resolving bottlenecks quickly and pushing programs forward with speed and discipline.

China's funding environment is a fifth factor. For pre-revenue companies, China has moved from a limited venture-capital market lacking an IPO pathway to a much broader financing base that includes venture capital, public markets, government funding, out-licensing, and commercialization. The diversity of funding mechanisms allows companies to tap different sources at different stages, giving them more flexibility to sustain innovation and push products forward. It also gives them options when private funding tightens.

Finally, China is expected to supply more than one-third of STEM graduates across the G20 by 2030, up from 29 percent in 2020. This depth of talent supports scientific capability and operational execution.

Businesses and policymakers face a choice in how to leverage China and what lessons to take from its model

This analysis indicates that biopharma R&D economics are not driven by wages alone. A large part of what distinguishes the industry in China comes from execution, its ability to compress timelines, use external partners effectively, and move programs through discovery and development with less friction. Speed matters twice—first by reducing cost and second by preserving more of a remaining commercial window.

For multinational pharmaceutical companies, the strategic question is how to leverage China. For some companies, the right choice will be selective participation in China through partnering, licensing, or local development. For others, China may become a true global R&D hub. And for others still, the main value may be in learning from China and adapting its speed, externalization model, and execution discipline elsewhere.

The degree of participation in China depends on how companies view a set of real risks. How durable is intellectual property protection, and how much value can be protected over time? How representative are clinical data generated in China when applied to broader global populations? How will European and US authorities respond to deeper China exposure as concerns around sovereignty, supply resilience, and public procurement increase? And how should companies think about the risk that a China-based competitor may access similar targets, move faster, and reach the market first?

For companies looking to learn from China, the opportunity is to borrow specific elements of the model and apply them in a global setting. The open question is how far this can go in practice. How do companies move faster without cutting corners? And how much of China's speed advantage can be translated into a multinational operating model, where governance, compliance, and incentives may be different?

How can governments support their biotech industries? Financial incentives matter, but they are not enough on their own. Promoting speed, scale, collaboration, and translating trials and tests into quick patient impact while maintaining patient safety are also critical.

Faster, clearer, and more predictable review processes reduce friction when development starts. Improving clinical-trial infrastructure, including site readiness, diagnostics, biomarker capability, and workforce training, can increase efficiency. More predictable demand, faster approvals, and clearer quality standards can help CROs, CDMOs, and clinical-site partners expand capacity, and stronger universities, training programs, and career pathways can increase scientific, operational, and clinical-development expertise. Stronger links between academia, hospitals, and industry can move promising science more quickly into development programs, clinical studies, and patient use.

China is not simply a lower-cost development base, it has a different model for building speed, capacity, and translation. For investors and CEOs, the question is how to leverage China's strengths selectively and learn from its operating model. For policymakers, the task is to create an ecosystem in which talent, trial infrastructure, specialist service providers, and regulation reinforce one another and allow companies to move quickly. The systems that move from promising science to patients faster will capture more value, attract more investment, help more patients sooner, and shape the next wave of innovation.

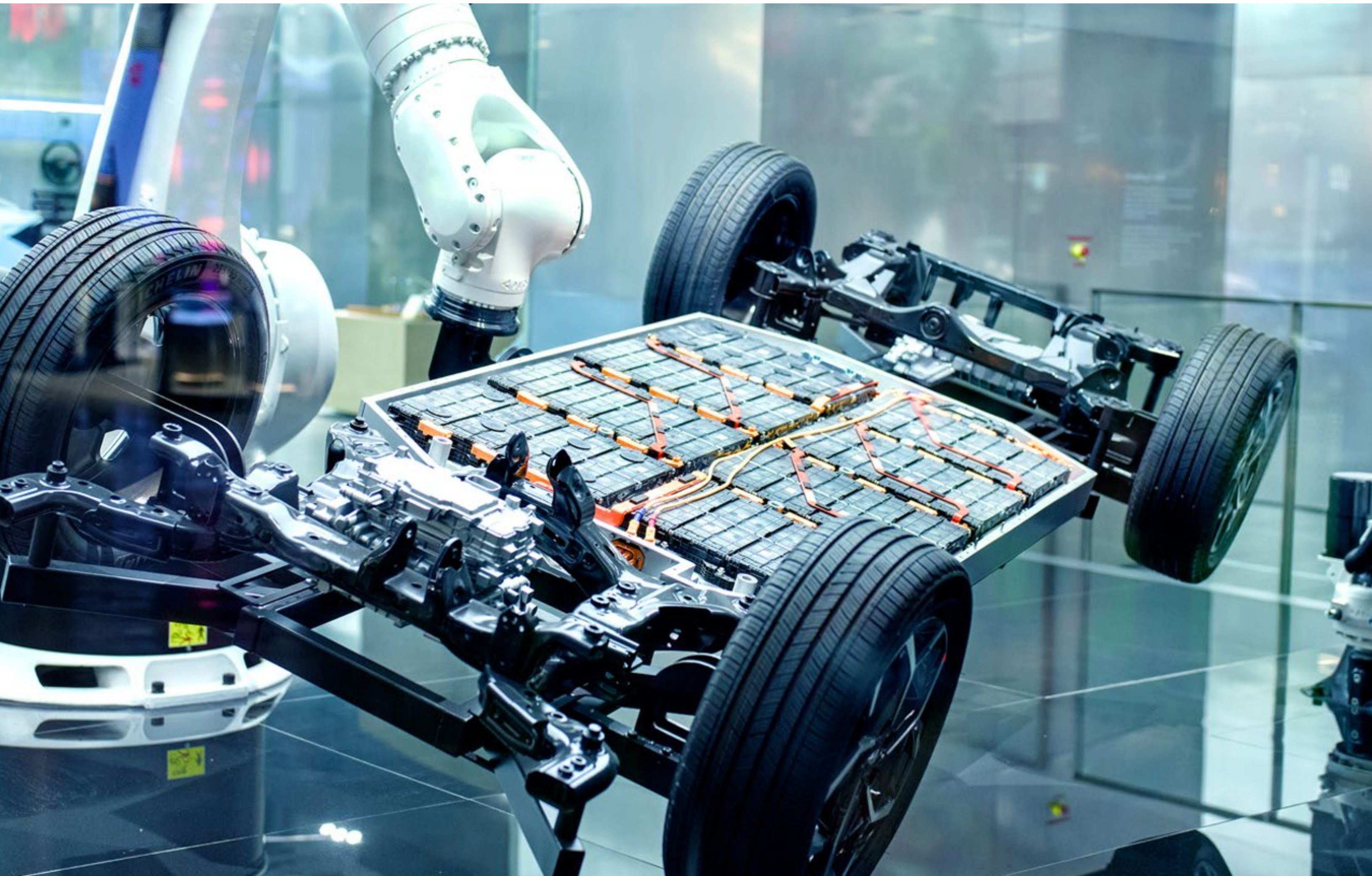
Gaurav Agrawal is a McKinsey senior partner based in the New York office, **Fangning Zhang** is a McKinsey partner based in Shanghai, **Anna Kortis** is a McKinsey partner based in the Vienna office, and **Olivier Bus** is a consultant based in the Amsterdam office.

Investment case

Automotive R&D: Charging ahead in EV platform development

Improvements in batteries and recharging, not to mention geopolitics, have increased consumer appetites for electric vehicles. Automakers are flocking to China for lessons in how to develop an EV platform.

by Johan Bengtsson, Ting Wu, Henrik Polzer, Anna Kortis, and Olivier Bus



Electric vehicles are gradually overtaking roads around the world, and plummeting recharging times, improving batteries, and scrambled oil trading patterns are providing additional tailwinds. One in four new cars sold in 2025 were EVs, and they have the potential to account for the majority of sales by 2035.[103] The EV industry is still absorbing losses related to intense price competition and high up-front platform and battery investments, and only a few original equipment manufacturers (OEMs)—such as Tesla, BYD, and Li Auto—have developed profitable EV business models. EV profitability is primarily driven by production economics, and automakers at large have challenges in supply chains, materials, design learning curves, and customer adoption. Profitable EV leaders all share one differentiator: unprecedented development. R&D cost and time to market have become major hurdles, as they struggle to make the right product and engineering choices, build necessary engineering skills, and align functions for faster execution. The outcome is longer development timelines that delay revenues and increase the risk that technologies are outdated by launch. While R&D accounts for only a relatively small share of total costs, the ability to develop and launch high-volume electric vehicle platforms quickly and efficiently becomes an important differentiator in who captures value in the next era of mobility.

This investment case is one of ten that are the foundation of the McKinsey Global Institute's report, *Catalyzing competitiveness: Where investment happens and why*. The report examines how investment propels competitiveness, and vice versa, by analyzing reasons for the variation in costs across industries in regions around the world.

The shift to mass-market EVs necessitates a new platform R&D paradigm, centered on software, scale, and speed

An EV platform is the underlying architecture that integrates a battery system, electric powertrain, chassis, electrical and electronic (E/E) architecture, and software that make up a vehicle. One platform serves as the foundation for various vehicle models and body styles in different regions over an extended production lifetime. Unlike platforms in internal-combustion-engine (ICE) vehicles, EV platforms must accommodate large battery packs to deliver competitive range, electric drive units configured across one or both axles, and more integrated thermal-management systems to manage battery performance, power electronics, and cabin conditioning.

As EV architectures evolve, platform choices are having a greater effect on cost and performance

Greenfield EV platforms require between $1 billion and $3 billion to develop, according to research by the McKinsey Center for Future Mobility. Up-front engineering, industrialization, and testing and validation costs must be amortized over a platform's lifetime. As a result, platform economics depend on utilization across multiple models and brands. Once developed, incremental vehicle derivatives can be launched at relatively low cost.

Demand for continuous innovation of EVs (and thus platforms) is being driven by improvements in battery and electric powertrain technologies that have made EVs economically viable at scale, reinforced by tightening emissions regulations and targeted government incentives. As EV adoption has moved from premium and early-adopter segments into the mass-market C/D (compact and mid-size mass-market car) segments, scalable and cost-competitive EV platforms have become critical.

Automotive manufacturers typically retain ownership of platform architecture, vehicle integration, and software. Suppliers have a critical role in codeveloping technologies that shape EV cost and performance. Tier-one suppliers contribute in areas such as electric drive systems, power electronics, and E/E architecture, while battery cell manufacturers influence platform economics and design through cell chemistry, form factor, and pack integration. Together, these suppliers help improve EV cost structures and push forward performance envelopes in areas such as energy density, efficiency, charging speed, and materials innovation.

China is setting the pace in EVs, while Europe and the United States race to catch up

Global investment in EV development has increased sharply over the past decade, reflecting OEM commitments to electrification and the need to replace multiple ICE platforms with larger-scale EV architectures to meet demand. Cumulative EV and battery investment commitments announced through 2030 total more than $1 trillion, with platform development absorbing a significant share of the investment for up-front engineering and industrialization.[104]

China produces more than 70 percent of EVs globally. Its leading brand, BYD, passed American Tesla's global sales of battery-powered EVs in 2025.[105] The growth of China's EV business is linked to its unrivaled cost structure, dense supplier ecosystems, strong access to critical materials, strong policy support for EV adoption, and a disruptive development philosophy that finds an optimum between speed, cost, and quality (detailed later in this article).[106] These factors enable companies like BYD and Xiaomi to lead in development times, which allows deployment of new technologies at an unprecedented rate, reducing time to revenue and increasing customer satisfaction.

Europe is home to several of the world's largest and oldest legacy automotive OEMs. As a result of more stringent CO_2 standards and zero-emission mandates, these incumbents have shifted large parts of their portfolios to dedicated EV platforms. However, EV platform development is based on long-standing product and development systems, which lead to much slower development timelines than those of EV-only disruptors.

The United States features a mix of legacy OEMs and EV upstarts, which primarily produce large pickups, SUVs, and premium cars. Federal incentives under the Inflation Reduction Act have accelerated domestic investment in battery plants and EV assembly capacity, although these have been phased out for consumer EVs.[107] However, customer adoption hasn't met expectations, and overall EV production remains well below China's, with legacy OEMs struggling to make investments in new EV architectures work.[108]

Beyond these economies, South Korea is home to competitive OEMs that work with world-class battery and component suppliers, shaping global benchmarks in battery integration and power electronics. Japan remains central to the global automotive industry through Toyota, the world's top-selling automaker, and a broader OEM base that continues to influence global vehicle architectures. However, Japan's electrification pathway has been more led by hybrids than by battery electric vehicles (BEV). Domestic hybrid sales exceeded two million vehicles in 2024, while EV and plug-in hybrid electric vehicle sales declined, reflecting more gradual BEV adoption and a continued role for plug-in hybrids.[109]

It is important to note that a platform may be engineered primarily in one country but assembled in several others. For example, an OEM may develop a platform in its home market, incorporating the design and various certification requirements across target sales geographies, and at the same time assemble vehicles based on that platform in multiple regions suitable for local demand. Automakers typically locate assembly close to major end markets to reduce logistics costs, manage tariff and trade exposure, and meet local content or policy requirements. This includes investments by Chinese carmakers in advanced economies, as well as more well-known cases where it is the other way around.[110]

Chinese EV OEMs demonstrate how faster innovation can reduce R&D costs

Our investment case evaluates the R&D cost of a global mass-market EV platform that supports multiple vehicle models. The case compares two archetypes, legacy OEMs and EV-focused disruptors, in China, Germany, and the United States. In this analysis, we split out the effects of drivers such as labor productivity, wage levels, and time to market to identify which are most important to competitiveness.

Assumptions about demand are held constant across geographies. Costs are expressed as the levelized R&D cost per vehicle manufactured. The platform is assumed to have a fixed life cycle that begins at the start of R&D, and yearly production volume is assumed constant across the remaining life cycle after R&D. In reality, production volumes may vary, and there are signs that some OEMs that specialize in EVs are breaking the traditional platform lifecycle through more incremental refreshes (see sidebar, Methodology).

Sidebar

Methodology

This investment case compares the costs of an electric vehicle platform project across various geographies to understand what makes some regions more cost-competitive than others. Our levelized cost methodology converts a project's full life cycle economics into a single unit cost. It can be interpreted as the unit price that would make a project's net present value equal to zero over its entire life cycle, which is the minimum price that makes that project viable and is in line with the macroeconomic concept of long run marginal costs. The levelized cost concept is commonly applied in the energy sector, where it is known as the levelized cost of energy. We do not consider taxes, subsidies, and externalities, which vary and are hard to pin down.

The calculations are informed by McKinsey's work in the electric vehicle industry, which provides our understanding of the capital expenditure, labor, energy, materials, and other inputs, as well as time, typically needed to build and operate an electric vehicle platform. We price the inputs at the typical costs in a geography, drawing on proprietary databases maintained by MGI's Economics Research team, and at the typical weighted average costs of capital, drawing on McKinsey's Value Intelligence platform, a curated database of the financials of companies globally.

The analysis covers platform R&D costs only, excluding industrialization, facilities, and manufacturing costs, to enable a more consistent comparison between established OEMs and disruptors. The costs of midcycle updates such as refreshes, derivatives, and facelifts are also excluded because they vary significantly across OEMs depending on platform life-cycle strategy and refresh cadence and can be difficult to attribute consistently to an underlying platform program. As a result of these choices, platform economics are driven by engineering and development activity rather than physical assets.

A Chinese EV OEM is our base case, representing best-in-class levelized R&D cost per vehicle. Chinese EV OEMs increasingly set the benchmark for development speed and cost competitiveness. Two broad archetypes stand out. The first includes more established OEMs, such as BYD, which combine rapid time to market with substantial in-house capabilities and vertical integration of key subsystems. The second includes EV-focused specialists such as NIO, XPeng, Li Auto, and, more recently, Xiaomi, which have often moved quickly by using supplier ecosystems selectively, limiting customization, and focusing internal resources on the technologies most central to differentiation. Our base case draws on the established model.

In the base case, labor costs account for the biggest share, roughly 40 percent, of levelized platform cost, reflecting the engineering-intensive nature of modern EV platforms. Software engineering represents the single largest slice of labor costs, because adoption of a software-defined vehicle program shifts development effort into platform-level software, including operating systems, foundational driver-assistance stacks, and over-the-air update infrastructure.

Prototyping and related tooling, which accounts for about 30 percent of levelized platform cost, includes building early test vehicles and parts as well as the tools needed to develop and refine them. This covers items such as prototype cars, battery packs, electronics mockups, and pilot tooling used before full production begins. Even with more virtual development, this remains an important cost because EV platforms still need real-world testing and repeated design fixes, especially for batteries, thermal systems, safety, and the way software works with hardware.

Software-related costs, accounting for about 15 percent, include high-performance computing, cloud computing and storage, and software licenses for simulation, software development, validation, and integration. These costs have increased markedly as EV platforms have become more sophisticated, requiring greater software functionality, tighter system integration, and expanded use of virtual engineering tools.

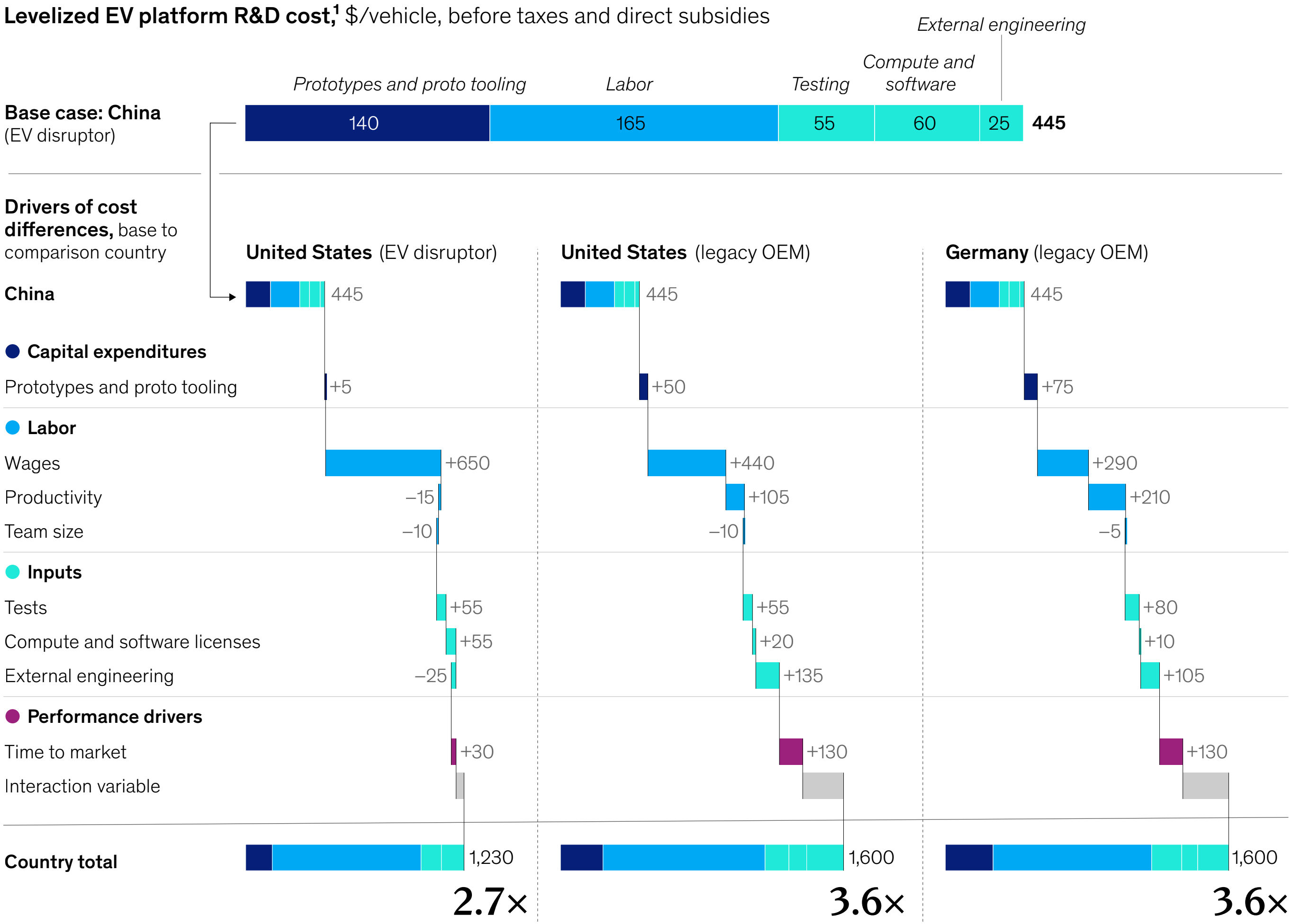
Testing and validation make up about 12 percent of levelized costs and include vehicle- and system-level activities spanning battery and E/E validation as well as a full set of certification and regulatory requirements, such as environmental, durability, and crash testing in all regions where a vehicle will be sold.

External engineering costs account for 5 percent of total costs and include codevelopment with suppliers, engineering service providers, and technology partners to supplement internal teams. In the base case, these costs are relatively low because Chinese OEMs are often more vertically integrated than their competitors. These OEMs typically launch platforms in 21 to 28 months, refining iteratively post-launch. This sets the benchmark for comparison (Exhibit 1).[111]

Exhibit 1

Wage differences and varying productivity are key determinants of the cost of developing an EV platform.

Levelized EV platform R&D cost,[1] $/vehicle, before taxes and direct subsidies



Note: Figures may not sum to 100%, because of rounding.
[1] Development of a platform to manufacture compact or midsize electric vehicles. The platform produces identical volume each year after launch and has a fixed end-of-life date.
Source: McKinsey Global Institute analysis

McKinsey & Company

R&D costs are three to four times higher for western legacy OEMs due to higher wages, lower productivity, and longer timelines
An EU or US legacy OEM's levelized EV platform development costs are roughly three to four times as much as the Chinese benchmark, reflecting a difference of about $1,200 per vehicle. This variation in R&D performance can drive a significant share of overall competitiveness, with the best-performing EV OEMs reporting operating profits ranging from zero to $4,000 per car.

Labor, which includes wage levels, productivity, and working hours, is the largest factor in the cost gap between Chinese EV platforms and those made elsewhere. Comparing Chinese and advanced economy OEMs, wage levels account for 30 to 50 percent of the difference. While productivity differences between regions are small within the same OEM archetype, productivity is significantly higher for EV disruptors than for legacy OEMs. This gap drives 10 to 25 percent of the difference between EV disrupters and legacy OEMs.

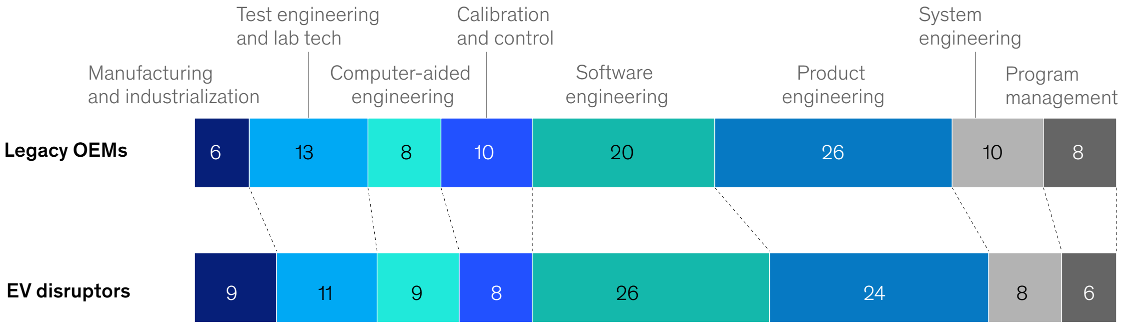
Legacy OEMs' productivity is lower because they commonly staff engineers across multiple concurrent programs and because they have more complex and slower established decision-making processes, adding switching costs that are uncommon at EV disruptors that have less need to move teams among projects.

Three other factors also unlock productivity for EV disruptors. They typically have flatter, engineer-led structures than legacy OEMs, reducing management layers and meeting overhead. They also deploy more software, systems, and vehicle control engineers, which shifts work toward scalable code and centralized architectures rather than needing repeated mechanical customization. Finally, the disruptors' much more extensive use of simulation and digital validation reduces late-stage rework and manual calibration. While legacy OEMs benefit from accumulated experience and established supplier ecosystems in areas such as interiors and infotainment, these productivity advantages are offset by the above factors. (Exhibit 2).

Exhibit 2

EV OEMs employ a different engineering footprint to accelerate time to market.

Engineering footprint by OEM archetype and discipline, %



Key differences between legacy and EV OEM operating models

Manufacturing and industrialization embedded from the start, developed in parallel with product design from day one

Digital-first validation, using early prototypes and simulations (often within 3 months) to enable rapid build–test–iterate cycles

Strong emphasis on software engineering with over-the-air updates and rapid feature releases, enabling earlier launch and continuous in-market improvement

Lean management and oversight, with flatter, engineer-led teams and decentralized decision-making

Note: Figures may not sum to 100%, because of rounding.
Source: McKinsey Center for Future Mobility Practice; McKinsey Global Institute analysis

McKinsey & Company

Time to market is the next largest contributor to the cost gap, accounting for 15 percent of the difference between the China base case and legacy OEMs in advanced economies, though that may understate this factor's competitive importance. Legacy OEM platform programs typically have required much longer development timelines, often 36 to 48 months before production starts. EV disruptors in China and the United States can achieve faster platform development, typically 21 to 28 months or even less to start production. This is achieved primarily through the Innovation Execution operating model and supported by a tight-knit EV development ecosystem.[112] In the Innovation Execution approach, design, validation, supplier tooling, and manufacturing readiness take place concurrently rather than sequentially. In tandem, small cross-functional core teams can make rapid trade-offs without multilayer approvals. Suppliers are embedded early as part of a development team rather than engaged only after specifications are locked. Finally, information is shared transparently across functions, enabling rapid feedback loops between design, testing, and cost engineering.

Earlier market entry translates directly into earlier revenue realization. Conversely, delayed launches shorten the effective competitive life of a given technology generation, reducing the time that a platform can capture full value before newer technologies and architectures emerge. Taken together, these effects materially increase levelized costs for programs with long lead times before production starts.

External engineering is the final major driver of difference, explaining 5 to 10 percent of the variation in levelized cost. Legacy OEMs rely more heavily on external engineering partners, especially for software integration, validation, and industrialization support. This provides flexibility but increases total development costs.

By contrast, some EV disruptors are more vertically integrated and do a larger share of development in-house or through tightly embedded suppliers, reducing reliance on external services. Additionally, external engineering capacity in China is often available at lower cost, particularly in the EV domain, thanks to a deep local talent pool and competitive service providers. Less reliance on outsourcing, combined with lower external rates, reduces overall platform development cost.

Other cost differences, such as for prototyping, tooling, testing, computing, and software licenses, are comparatively small. However, differences in prototyping approaches influence development speed and iteration cycles. EV disruptors make more extensive use of digital engineering tools, including simulation, virtual validation, and software-in-the-loop testing, which reduces the need for physical prototypes. In China, disruptors also benefit from dense local supplier ecosystems, particularly around Shenzhen. This makes it much easier to source prototype electric motors, battery cells, and power electronics more quickly than in ICE-based heritage ecosystems such as Michigan's. Finally, legacy OEMs often retain conservative prototyping and testing practices linked to historical incidents or litigation rather than to current regulations, while EV disruptors often have leaner, requirement-driven validation approaches. While these advantages are not the main drivers of total platform cost, they do contribute significantly to development speed and the time-to-market advantage.

Overall, differences in organizational speed, labor economics, and execution models explain the majority of the gap in EV platform development costs. This is also substantiated by the fact that US EV disruptors can achieve productivity and time-to-market performance similar to Chinese EV disruptors. If legacy OEMs can replicate key elements of the Innovation Execution operating model and develop ecosystem advantages similar to China, they could feasibly close more than half of the current cost gap in EV platform R&D.

Legacy OEMs can narrow the gap by rethinking how they define ambition, make decisions, and structure accountability

Cost and timeline differences explain only part of the competitiveness gap. The deeper distinction is explained by how organizations set ambition, make decisions, and structure accountability.

Use of the Innovation Execution operating model involves targeting ambition in ways that encourage structural change, such as double-digit annual cost reduction and improvements that result in step changes in performance. These stretch targets are not always financial aspirations but rather operational constraints that inform engineering choices from day one. The targets account for forward-looking market influences like customer preference and potential moves by competitors, focusing outside-in rather than only on current internal capabilities.

EV disruptors anchor engineering in first principles rather than incremental optimization. Teams are encouraged to redesign subsystems from scratch, challenge legacy assumptions, and simplify architectures aggressively. This approach reduces complexity that can accumulate over time and leads to structural cost and performance gains. A famous example is Tesla leveraging its vision sensor to detect rain, thereby eliminating the need for a rain sensor.

Accountability is also structured differently. Small, fully dedicated teams have end-to-end responsibility for cost, performance, and delivery. If one subsystem misses its target, the full team is accountable. This eliminates functional silos and replaces consensus-driven alignment with team and employee ownership of decisions.

That's not to say there's no role for leadership. Senior executives are heavily involved in product definition and problem solving, as well as reinforcing urgency and removing organizational barriers. Culture is built around fast issue resolution, short feedback loops, and visible progress rather than formal approval rituals. Full transparency built through digital solutions makes this possible. If a team and management understand the current status at all times, they can more quickly jump into solving a problem rather than coming to a solution only after a series of updates.

Such differences are not dependent on geography. They are managerial choices. More than half of the competitive advantage in EV platform development is a result of how work is organized and overseen, not inherent technological or regional constraints.

The realization that time to market is a competitiveness driver should inform corporate action and policy design

Our research indicates that platform economics and competitiveness aren't determined only by structural factors but also largely by execution capabilities that are specific to a company. The majority of an EV platform's capital efficiency depends on an OEM's or disruptor's ability to compress development timelines, minimize organizational friction, and fully exploit software-centric architectures. As a result, comparisons of labor costs or regional incentives can be misleading if not paired with a granular understanding of operating models.

Businesses could prioritize the following:

- Short development cycles and rapid iteration, underpinned by parallel engineering and early supplier integration
- High software intensity and redeployment at the platform level, consistent with software-defined-vehicle principles
- Dedicated, accountable teams
- Tight ecosystem integration to enable rapid prototyping and fast feedback loops

Importantly, legacy OEMs that reform their governance structures, simplify validation regimes, and adopt Innovation Execution development practices may unlock substantial value. Conversely, those that fail to adapt risk structural disadvantages, even in markets where policy support is favorable.

For policymakers, the analysis highlights that financial incentives and industrial policy alone won’t ensure global competitiveness in EV platform development. While subsidies, tax credits, and mandates to localize can influence where investment is made, they don’t address organizational and ecosystem factors that drive speed and capital efficiency. As time-to-market is one of the key competitiveness levers, regulatory frameworks that inadvertently reinforce sequential development, excessive revalidation, or fragmented accountability may unintentionally disadvantage domestic OEMs relative to faster-moving global competitors.

Policies that could overcome these challenges include the following:

- Regulatory clarity and harmonization to reduce the need for conservative, legacy-driven validation practices
- Encouragement of digital-first development practices, including virtual testing and simulation infrastructure
- Talent mobility and skills development, especially in software, systems engineering, and digital validation
- Support for building out dense supplier ecosystems, particularly in batteries, power electronics, and software tooling

The next phase of EV platform development will not unfold evenly across regions or companies. New entrants have disrupted the market and raised expectations for speed from concept to launch. Automakers that want to remain competitive will need to adopt new ways of working that shorten development cycles and reduce costs, while policymakers can help create the conditions for faster innovation.

Johan Bengtsson is a McKinsey partner based in the Stockholm office, **Ting Wu** is a McKinsey partner based in the Shenzhen office, **Anna Kortis** is a McKinsey partner based in the Vienna office, **Olivier Bus** is a consultant based in the Amsterdam office, and **Henrik Polzer** is an associate partner based in Stockholm.

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A new cartography of competitiveness

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Chapter one

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