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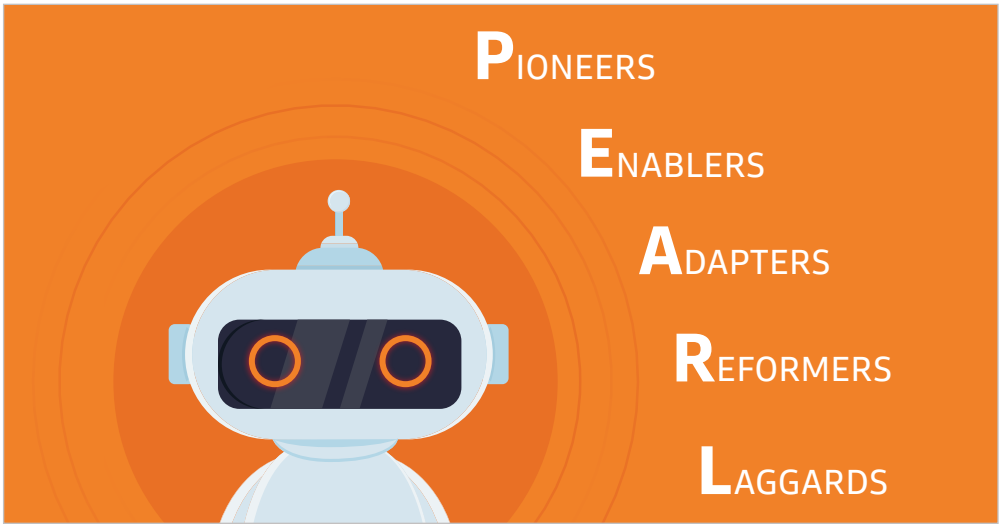
Why AI is not a Bubble



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- The growing narrative about the potential for artificial intelligence (AI) has raised questions about its broader impact on equity markets, the concentration of market leadership, and the potential for another bubble.
- Previous major new technology waves have generally driven outperformance of the technology sector and pushed valuations higher, attracting new entrants and, ultimately, fuelling a bubble.
- The bursting of bubbles has typically been followed by a renewed period of leadership, with a new group of dominant companies emerging in the sector, and the impact of the technology reshapes other industries.
- Technology is already the biggest sector (in the US market at least) and stock concentration has increased, but this is not unusual relative to previous experience of new innovations.
- Current valuations in the technology sector are not as stretched as in previous bubble periods and the 'early winners' that have enjoyed the strongest returns have unusually strong balance sheets and returns on investment.
- We believe we are still in the relatively early stages of a new technology cycle that is likely to lead to further outperformance.
- We focus on our **PEARLs framework**, differentiating between the early **Pioneers** and innovators of the technology, the critical **Enablers** that facilitate commercialisation of the technology, **Adaptors** that change their business models to adopt the new technology, the **Reformers** that disrupt and re-shape older industries and gain market share, and the **Laggards** – mainly in the tech sector – that are slow to compete as technologies change.
- We have already seen significant re-ratings of a few companies that can be viewed as 'early winners', mainly Pioneers and Enablers. These are likely to continue to outperform as the technology scales. In time, the bigger opportunities may be found in identifying the new Reformers that re-shape industries by leveraging what AI has to offer. Best-in-class Adaptors with industry-leading execution are likely to provide an attractive investment opportunity. However, as many companies adapt to AI, increasing benefits should feed through to consumers. Companies that can tap into this opportunity could also benefit more than the market is currently discounting.

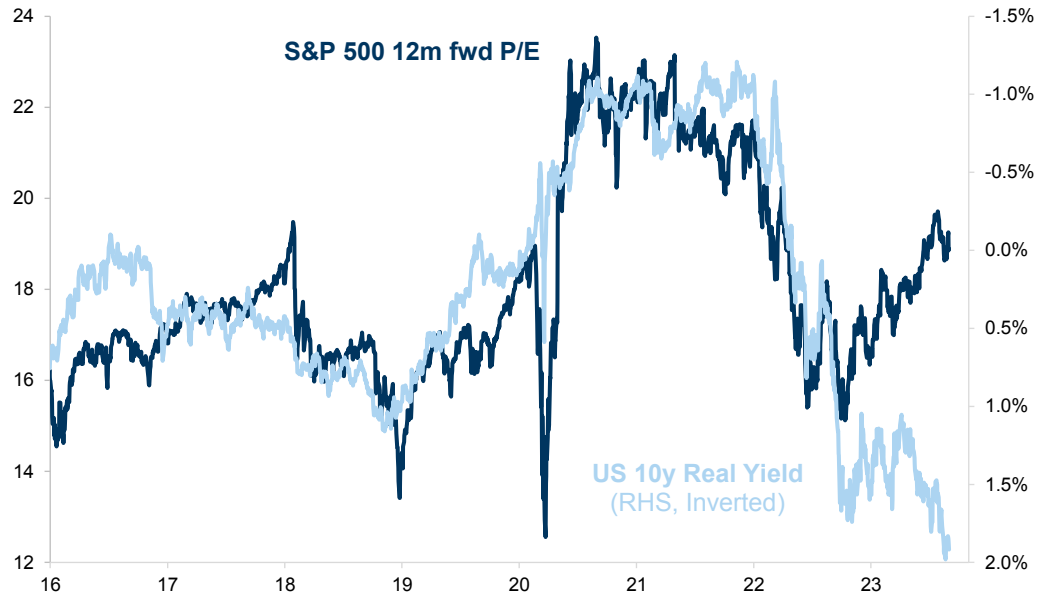
Why AI is not a bubble

The explosion of interest in AI that has dominated equity markets in recent months reflects the potential for new avenues of growth and, at the same time, the power of a stock market narrative to drive expectations.

While AI as a technology is not new, the interest around its potential has gathered momentum since the launch of ChatGPT. This exuberance has fuelled a re-rating in the technology sector overall, but particularly in the easier to identify 'early winners' — companies innovating and investing heavily in the technology, and those that are enabling its commercialisation.

The outperformance of the technology sector (the Nasdaq, for example, is up 42% this year and the MSCI World up 15%) has occurred despite the impact of higher interest rates. This is very different from the experience of 2022 when higher interest rates, driven by the rise in inflation, prompted a de-rating of the technology sector owing to its 'long duration', or sensitivity to rising discount rates (Exhibit 1). The implication is that investors are assuming much higher future growth rates to offset higher discount rates.

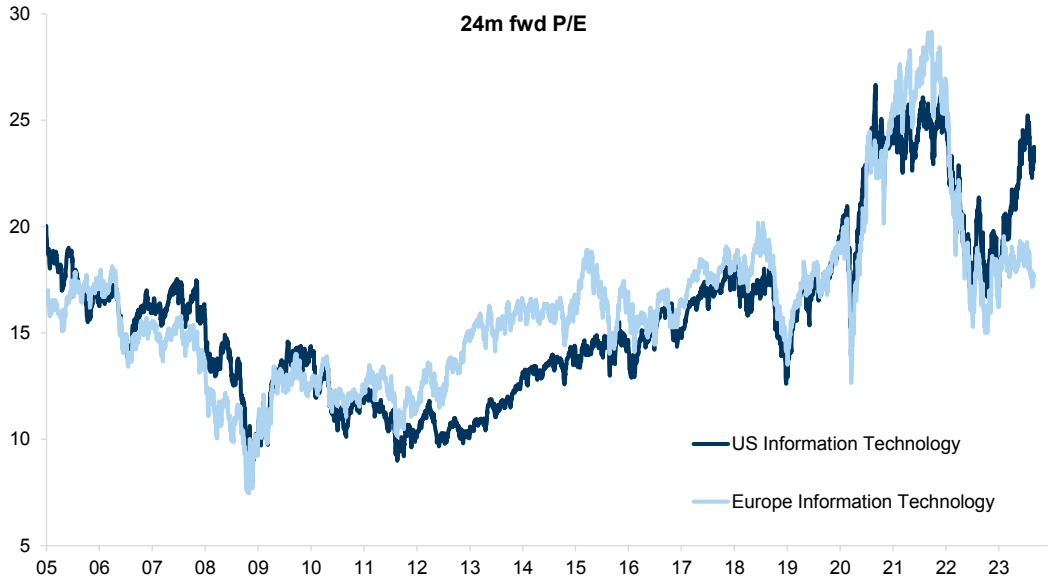
Exhibit 1: The S&P 500 P/E has moved up despite the increase in yields
S&P 500 12m fwd P/E and US 10y real yield



Source: FactSet, Bloomberg, Goldman Sachs Global Investment Research

The small group of 'early winners' have driven valuations in US technology stocks (seen as the epicentre of the new technologies) to an unusual premium relative to technology companies elsewhere. For example, as Exhibit 2 shows, US technology sector valuations have increased relative to those in Europe this year, suggesting that the AI narrative has been a key factor given that most of the leading companies investing in this space currently are in the US.

Exhibit 2: The valuation of the US technology sector have increased relative to Europe
24m fwd P/E, S&P 500 and MSCI Europe Information Technology

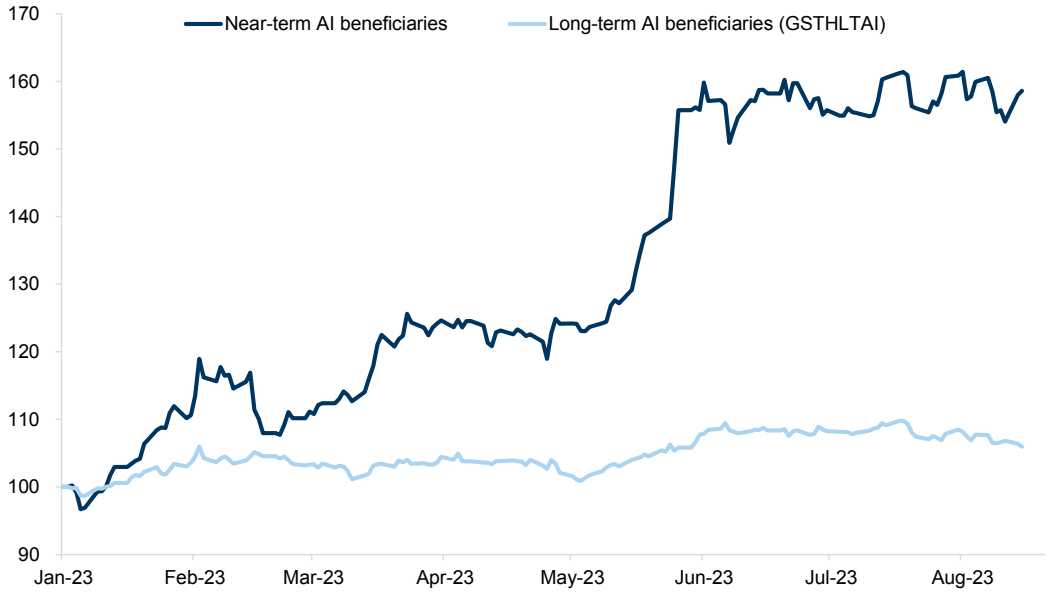


Source: FactSet, Goldman Sachs Global Investment Research

Our US equity strategists recently highlighted a list of 11 US stocks that they view as potential near-term beneficiaries of the AI revolution. They include the makers of semiconductors and related equipment needed to build AI technology: Nvidia (NVDA), Marvell Technology (MRVL), and Credo Technology Group (CRDO); hyperscalers and the mega-caps that use their extensive cloud computing infrastructures to commercialise AI on a large scale: Microsoft (MSFT), Alphabet (GOOGL), and Amazon (AMZN), and empowered users: companies that are currently leveraging AI technology to amplify their businesses: Meta Platforms (META), Salesforce (CRM), Adobe (ADBE), ServiceNow (NOW), and Intuit (INTU).

As our US colleagues have shown, this group of 'early winners' has already appreciated sharply, returning roughly 60% YTD (Exhibit 3).

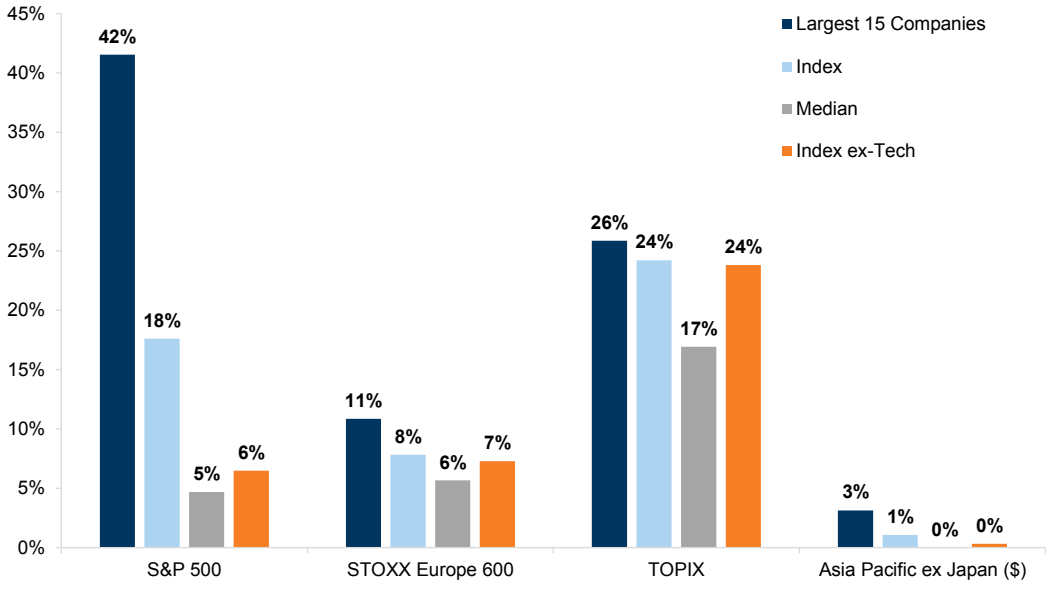
Exhibit 3: A group of 'early winners' has already appreciated sharply
Performance of near-term vs. long-term AI beneficiaries



Source: Goldman Sachs Global Investment Research

Since many of these early winners are very large companies, the concentration of the returns in the equity market this year has been extraordinarily high: for example, just 15 companies in the US accounted for over 90% of the S&P 500 return between January and June of 2023.

Exhibit 4: The concentration of the returns in the equity market this year has been extraordinarily high
YTD price return (local currency, $ for Asia Pacific ex Japan). Largest 15 companies by market cap size



Source: Datastream, STOXX, Goldman Sachs Global Investment Research

Many investors question the sustainability of this narrow leadership, the higher valuations and the potential for another technology bubble, with comparisons being

made to the mania for everything tech-related in the 1990s. Like many bubbles built around new technologies throughout history, the tech bubble of the late 1990s was not without foundation. Investors correctly recognised that a major new cycle of innovations would have a profound impact on growth and profitability in the future. The problem was that the scale and timing of the likely returns were overstated at the time, and many of the eventual winners did not yet exist.

When the bubble burst, in common with many others in history, it wiped out many of the new entrants that were not yet profitable. Despite the spectacular collapse, the technologies that drove the bubble (the internet in particular) survived and thrived as the sector re-emerged as the main driver of performance and profits in the post-financial-crisis period.

While tech stocks have been the main driver of equity market returns since the financial crisis of 2007/08, their performance has come in four distinct phases:

2010-2019 — Outperformance driven by stronger earnings, the widespread adoption of smartphones, the impact of zero interest rates and the problems facing 'value' sectors.

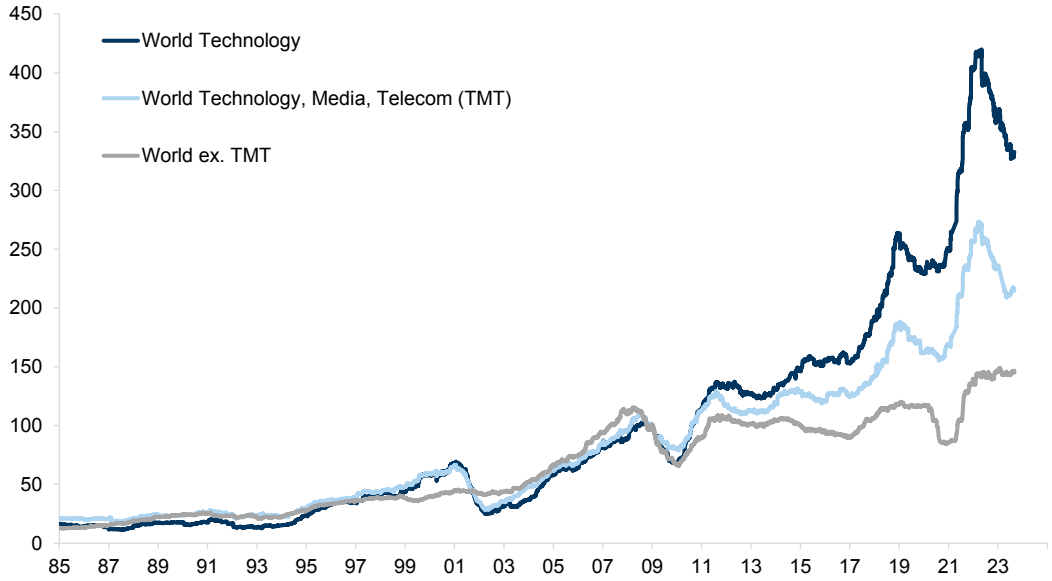
2020-2022 — During the Covid-19 pandemic, the explosion of demand for technology and related services (at a time when other consumption was restricted) led to a significant outperformance of technology companies.

2022-2023 — As inflation and rising interest rates began to emerge in 2022, technology companies experienced a sharp pullback in performance, particularly in non-profitable tech companies, as they buckled under the weight of a higher cost of capital and negative impact on their 'long duration' cash flows. Many had also overextended, buoyed by the cheap cost of capital, and needed to reduce spending as funding costs increased.

2023-now — Since the start of this year, the technology sector has begun to outperform again, driven by the large US technology companies, viewed as potential winners from the emerging technologies around artificial intelligence.

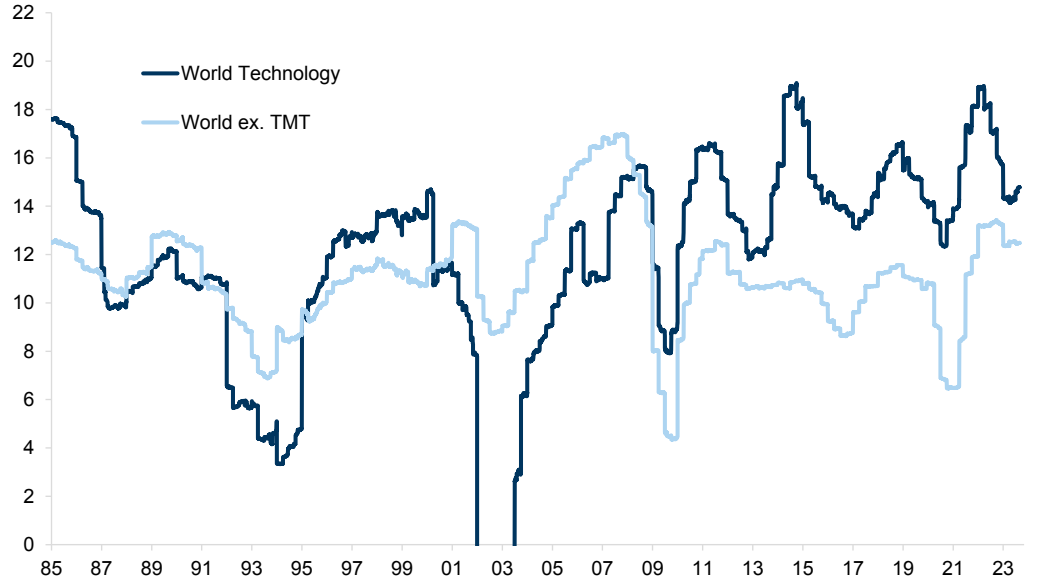
So, while the outperformance of the technology sector over the past 15 years as a whole has reflected bouts of optimism and valuations re-rating, it has mainly relied on strong underlying fundamentals. The sector has outgrown and out-earned other parts of the equity market (Exhibit 5), enjoying sustainably higher return on equity (Exhibit 6).

Exhibit 5: The sector has outgrown and out-earned other parts of the equity market...
12-month trailing EPS ($). Indexed to 100 in January 2009



Source: Datastream, Worldscope, Goldman Sachs Global Investment Research

Exhibit 6: ...enjoying sustainably higher return on equity
12-month trailing Return on Equity (%)



Source: Datastream, Worldscope, Goldman Sachs Global Investment Research

Where to look for signs of a technology bubble

Despite the strong fundamentals of the technology sector, several of the factors that drove the cycle in the late 1990s are similar to those that we see today; a step change in technology seems to be at a critical point of commercialisation, bringing the potential for higher future growth. The problem now, as then, is how to value the scale of the

benefits that will accrue and identify who will be the biggest winners (and losers).

Looking at history (see Why Technology is not a bubble; lessons from history), we can make several interesting observations about how these periods evolve that help to contextualise the speed of change we are experiencing across economies and society today. Although it is difficult to generalise, some common characteristics are:

- A breakthrough technology emerges and reaches commercial scale.
- New companies and capital flood into the space.
- Speculation builds and valuations of companies rise, often resulting in a bubble.
- The bubble bursts, but the technology tends to re-emerge as a principal driver in the economy and stock market.
- The technology/industry becomes dominated by a few large players.
- Secondary innovations emerge, creating new companies and products that are enabled by the initial technology and its increased adoption.
- Other industries are disrupted by the innovations, forcing incumbents either to adapt or disappear.
- The secondary innovations create new employment opportunities and, with them, new sources of demand. Productivity tends to rise, but usually only after the full adoption of this new technology and network effects are realised.
- The speed of innovation is often associated with significant changes in broader society, seen in shifting social attitudes, consumer behaviour, government policy and business practices. These create new challenges and opportunities for companies adjusting to meet the changing demands.

Exuberance, speculation, and bubbles

As we saw with the scaling and commercialisation of the internet and, more recently, with AI, the emergence of a significant new technology often results in growing investor exuberance, the injection of significant capital and a rapid expansion in the number of new entrants to the industry. As the understanding and acceptance of the technology grows, investor interest deepens and speculation increases.

Option value: From an investor perspective, the success and eventual impact of an innovation cannot be known at the outset, and it is even more challenging to predict which competitor is likely to succeed over the long run, leading investors to invest across multiple companies as options on their future success. Consequently, the total valuation of companies exposed to the theme as it first becomes commercial often overstates the aggregate returns that can be generated, and a bubble emerges; the bursting of the bubble is often triggered by a prominent company failure or a sharp shift in the cost of capital.

There are plenty of historical examples to illustrate this process. A study found that, in a sample of 51 major tech innovations introduced between 1825 and 2000, bubbles in

equity prices were evident in 73% of the cases.[1] The innovation of canals for transportation was an important component of the First Industrial Revolution. The first canals built generated strong returns for investors, attracting new inflows of capital that pushed up prices, and during the 1790s a bubble developed in canal stocks on the London Stock Exchange. The boom in canal stocks reached a peak in 1793. By the 1800s, the return on capital in canals had fallen from a pre-bubble peak of 50% to just 5%, and a quarter of a century later only 25% of canals were still able to pay a dividend. Nevertheless, the canal infrastructure became instrumental in reorganising industries and factories, which, in turn, spawned the growth of many new industries, businesses and products.

A similar exuberance surrounded the growth of railways in the nineteenth century, which were to become equally transformative in terms of economic growth, business organisation and societal change. Rampant speculation built up in railway stocks in the UK and by the 1840s a bubble had formed as money flooded into the sector in search of high growth and returns. Following significant price rises, railway shares fell by an average of 85% from their peak by the 1850s and the total value of these shares had fallen to less than half the capital spent on them.[2] As with the canals, the legacy of the infrastructure became pivotal to growth in other industries.

The twentieth century brought sequential waves of new technologies. The periods after World War I and World War II saw massive demand for consumer products that attracted waves of investment as new entrants emerged. As broadcast radio took off, for example, demand for radios increased rapidly. Between 1923 and 1930, 60% of US families purchased radios, which resulted in a proliferation of radio stations. In 1920 US broadcast radio was dominated by KDKA but, by 1922, 600 radio stations had opened across the US and, as with the adoption of television technology, this increased the scope for advertising and the adoption of other products as they came to market. The value of shares in the Radio Corporation of America (RCA), for example, rose from $5 to $500 in the 1920s but collapsed by 98% between 1929 and 1932, and most radio manufacturers failed.

The personal computer (PC) revolution fuelled a similar boom in both the number of companies and valuations of new entrants in the market. While IBM facilitated the widespread commercialisation of the personal computer, hundreds of companies entered the market in the 1980s. In 1983, however, several companies in the sector announced losses, including Atari, Texas Instruments and Coleco. A collapse in PC share prices followed and many PC manufacturers went out of business, including Commodore, Columbia Data Systems and Eagle Computer. While many of the surviving businesses took many years to recover, the industry matured and became dominated by just a few companies.

This pattern was repeated during the internet bubble of the late 1990s. Speculation

[1] Chancellor, E., and Kramer, C. (2000). Devil Take the Hindmost: A History of Financial Speculation. Finance and Development, 37(1).

[2] Odlyzko, A. (2000). Collective hallucinations and inefficient markets: The British railway mania of the 1840s. SSRN Electronic Journal.

grew rapidly as investors began to see the potential of the internet. When search engine company Yahoo! had its Initial Public Offering, its stock rose from $13 to $33 in a single day. Qualcomm shares rose in value by over 2,600%, 13 major large-cap stocks increased in value by over 1,000%, and another seven large cap stocks each rose by over 900% in 1999. The Nasdaq index increased fivefold over the period between 1995 and 2000. In just a month after its peak in 2000, the Nasdaq had fallen 34% as hundreds of companies lost 80% or more of their value. The Nasdaq itself had fallen by nearly 80% by the time it troughed in October 2002.

Bursting the speculative bubble: As a rule, excitement around the potential from new technologies attracts new entrants and competitors, as well as increased speculation as interest in the narrative grows and investors fear missing out. Ultimately, valuations will tend to adjust downwards, a shake-out of the industry results in fewer competitors, and the industry tends to recover, often leading the next cycle. This pattern was true for the technology sector after the tech bubble burst, and it is likely that the latest innovations, particularly around artificial intelligence, will be similar and make major contributions to the return prospects for investors in what we have dubbed the Post-Modern Cycle.

The read-across here is that the companies that are spending the money on AI tools and the compute power may not be the biggest winners from the new technologies over time, as we saw with the experience of the development of the internet, for example. As our Global Markets colleagues show in their paper, companies that can use the tools to improve healthcare and education services for example, may end up as big winners, together with other companies that can adopt AI solutions to significantly restructure businesses to reduce costs. Innovators in new business growth areas, such as data and fact-checking, may ultimately thrive. Finally, many of the benefits may accrue to consumers in the form of cheaper new services.

The dominance effects

Radical new technologies tend to attract significant capital and competition, and many companies eventually collapse, but this does not mean that the technology itself fails. It is more common for the initial technology to succeed as take-up and market grow, and dominant companies innovate to broaden the scope and reach of the technology. The adoption speed of technologies has tended to accelerate over time as real incomes have increased and geographical reach has grown more rapidly.

As a rule, the pattern of changing market structure tends to be similar in different waves of innovation; initially, the space is typically dominated by a few winners that become increasingly powerful as the network effect generates a virtuous cycle of growing market share and as they build increased 'moats' that sustain their dominant position. These dominant positions are ultimately vulnerable either to regulation (antitrust) or slow adaption to innovations.

The emergence of secondary technologies

While the market for a technology innovation can become dominated by a few very large companies for a long time, the initial transformative technology becomes a conduit that

kickstarts a whole range of other innovations and, with this, new companies and market opportunities.

For example, while coal and steam were the foundations of the First Industrial Revolution, a range of other developments quickly followed. Mass migration to cities and the movement away from agriculture resulted in demand for new consumer products. Mechanised looms transformed the textile industry and domestic products such as soaps began to be manufactured in factories rather than at home. This generated new markets and became the catalyst for the building of consumer brands, advertising, and marketing. During the railway boom, the steam engine spawned the development of the railways, and the network effect and connectivity then allowed other technologies to develop.

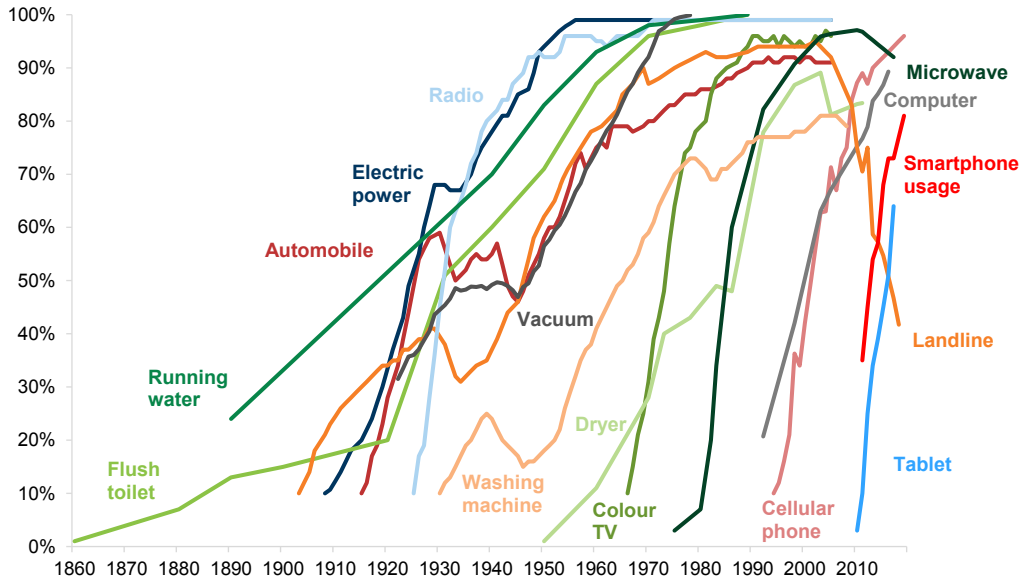
Similarly, during the Second Industrial Revolution, the harnessing of gas and oil to create electricity was one of the key driving inventions. But this, in turn, enabled the mass production of steel, the development of the internal combustion engine and the automobile. The start of the modern assembly line in factories became a further innovation, transforming the production and distribution of a range of new products. In the same way, the network impact of the railway boom and telegraph fostered a host of new market opportunities and companies.

With the computer age of the Third Industrial Revolution came the rapid acceleration of service industries. The first transistorised consumer products started to appear in 1952, opening new markets as consumers were willing and able to pay a premium for low power consumption and portability. By the mid-1950s, prototype silicon devices were developed in Northern California. Plastics and lighter materials also generated significant new growth markets, while the growth of multinational companies opened new market opportunities.

This pattern has also been evident over the past two decades. The rapid rollout and adoption of the internet and related technology has enabled the development and penetration of the smartphone. This, in turn, spawned an industry of companies based on the 'apps' used on these phones (think of the revolution in taxi and food delivery services, for example) and the 'internet of things' (a world of connected appliances and devices).

So, while the leading tech companies of the 2020s will most likely remain dominant in their respective markets, rapid innovation, particularly around machine learning and AI, will likely create a new wave of tech superstars and possibly products and services that are not yet imagined. It is probable that AI and robotics will not only create innovative leading companies but will also raise the prospect of major restructuring gains in non-technology sectors.

Exhibit 7: The adoption speed of technologies has tended to accelerate over time
Share of US households using specific technologies, 1860 to 2019

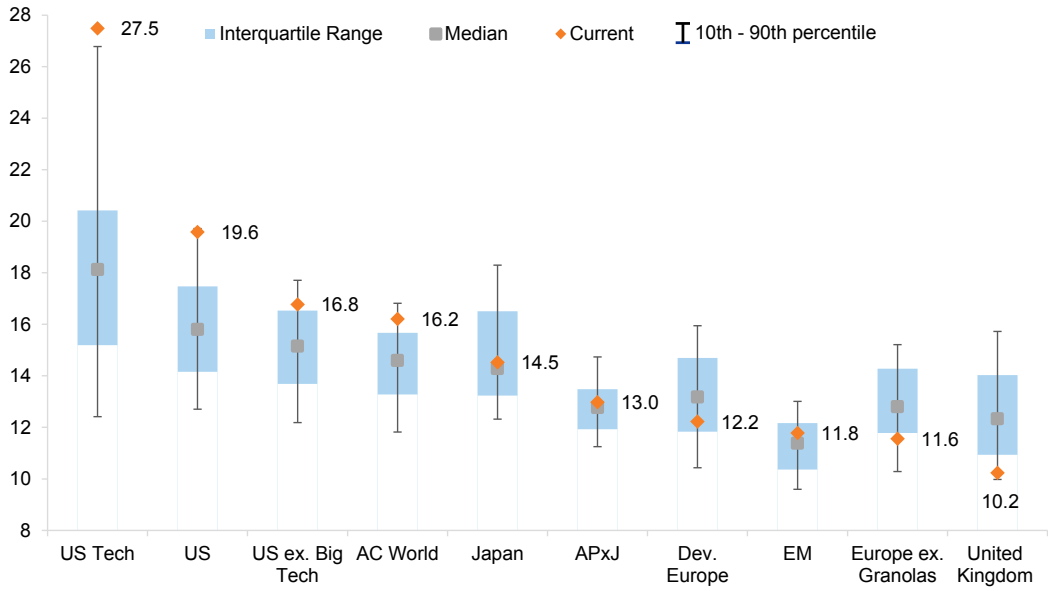


Source: Our World in Data, Goldman Sachs Global Investment Research

Are current valuations at bubble levels?

Given the patterns that have tended to exist in technology cycles in the past, an obvious question is whether the technology sector is currently in a bubble. There is no doubting that valuations in the technology sector are high by historical standards. Exhibit 8 shows the current valuations of various markets relative to their 10-year median and their range over that period. Technology is right at the top of its range — a key factor behind the S&P also being expensive relative to its experience over the past couple of decades. Other markets with less tech exposure are less stretched. Europe remains below average valautions, and when we look at it excluding the biggest companies – the GRANOLAS (largely defensive growth companies in the tech sector, together with healthcare, consumer staples, and luxury) – it trades at 11.6x earnings, still well below its averages.

Exhibit 8: The valuation of US technology is at the top of its range
12m fwd P/E multiple. MSCI Regions



Source: FactSet, Goldman Sachs Global Investment Research

A key driver of these valuations, however, is a small group of particularly 'early winners', often seen at the forefront on AI. Nevertheless, these dominant companies remain at much lower levels than the biggest companies in other periods in the past. For example, as Exhibit 9 shows, the seven biggest US tech companies that are often viewed as being at the vanguard of AI currently have an average P/E of 25x, with an EV/Sales of 4x. This compares to a P/E of 52x at the peak of the tech bubble for the biggest companies which, at the time, had an EV/Sales of over 8x. The leading companies in the Nifty 50 bubble of the late 1960s had a P/E of over 34x.

Also worthy of note is that the biggest companies in Europe (not all of which are tech) have a much lower valuation than the equivalent list of dominant companies in Europe during the tech bubble of the late 1990s (see Exhibit 10). So, not only are the leading tech companies less extreme in valuation today, but the broader optimism that spilled over into equity valuations overall in the late 1990s is not apparent today.

Exhibit 9: Dominant companies today are not as expensive as those in previous 'bubble' periods in history

US	Size		Valuation	Valuation
	Market weight	Market Cap ($ Bn)	*24m fwd P/E	24m fwd EV/Sales
Big Tech				
Apple	7.9%	2962	26.4	7.1
Microsoft	6.5%	2442	25.1	8.8
Alphabet	4.2%	1598	18.3	2.0
Amazon	3.8%	1425	34.2	2.2
NVIDIA	3.2%	1198	26.6	14.1
Tesla	2.1%	778	41.7	5.0
Meta Platforms	1.7%	659	15.8	4.0
Big Tech Aggregate	**29.3%**	**11062**	**24.9**	**4.4**
Tech Bubble				
Microsoft	4.5%	581	53.2	19.2
Cisco Systems	4.2%	543	101.7	17.5
Intel	3.6%	465	42.1	11.5
Oracle	1.9%	245	84.6	19.0
IBM	1.7%	218	23.5	2.3
Lucent	1.6%	206	37.9	4.1
Nortel Networks	1.5%	199	86.4	6.4
Tech Bubble Aggregate	**19.0%**	**2457**	**52.0**	**8.2**
Nifty 50				
IBM	7.1%	48	35.5	
Eastman Kodak	3.6%	24	43.5	
Sears Roebuck	2.7%	18	29.2	
General Electric	2.0%	13	23.4	
Xerox	1.8%	12	45.8	
3M	1.4%	10	39.0	
Procter & Gamble	1.4%	9	29.8	
Nifty 50 Aggregate	**19.9%**	**135**	**34.3**	

*Actual P/E for Nifty 50

Source: Datastream, FactSet, Goldman Sachs Global Investment Research

Exhibit 10: Dominant companies today are not as expensive as those in previous 'bubble' periods in history

Europe	Size		Valuation	Valuation
	Market weight	Market Cap (€ Bn)	24m fwd P/E	24m fwd EV/Sales
Europe's Top				
Novo Nordisk	3.0%	300	27.7	7.6
Nestle	3.0%	295	19.1	3.3
ASML	2.2%	247	23.0	7.4
Novartis	2.2%	213	12.6	4.1
LVMH	2.2%	389	20.2	4.1
Roche Holding	2.1%	193	7.7	0.7
Shell	2.0%	191	12.1	3.1
Europe's Top Aggregate	**16.7%**	**1827**	**21.5**	**3.4**
Europe's Top - Tech Bubble				
Vodafone	4.2%	347	55.9	14.4
Nokia	3.9%	272	61.5	7.2
Ericsson	2.7%	186	60.1	4.6
BP	2.5%	173	17.9	1.8
BT Group	1.9%	134	31.7	3.8
Deutsche Telekom	1.4%	265	84.0	7.4
Orange	0.8%	196	55.7	6.3
Europe's Top - Tech Bubble Aggregate	**17.3%**	**1572**	**71.7**	**7.8**

Source: Datastream, FactSet, Goldman Sachs Global Investment Research

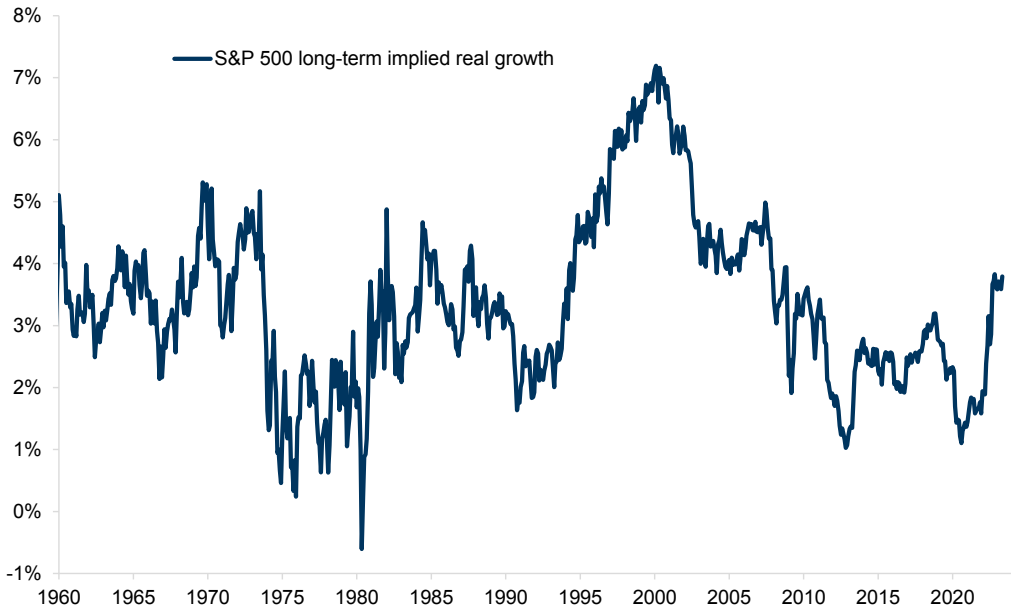
Another way of looking at how 'bubble-like' valuations are is to extract the implied future

growth priced into stocks. A crude way of doing this is to use the Gordon growth model and assume that the ERP is fixed:

Long-term implied real growth = Equity Risk Premium (ERP) + 10-year yield - dividend yield - 10-year breakeven

Exhibit 11 shows this implied long-term growth for the S&P 500 assuming a fixed ERP of 4% over time. This suggests that long-term growth expectations have increased recently (so offsetting the impact of higher bond yields), but much less than the expected annual growth implied in the late 1990s.

Exhibit 11: Implied long-term real growth for the S&P 500
Assuming fixed ERP of 4%



Long-term implied real growth = ERP + 10-year yield - dividend yield - 10-year breakeven

Source: Datastream, Goldman Sachs Global Investment Research

Strong fundamentals support valuations

Aside from their valuation, an important difference between the current leaders in the AI technology space and those in the late 1990s bubble is that the current crop of leaders is already very profitable and cash-generative, and they are able to invest at a high rate even in an environment of higher interest rates.

For example, Exhibit 12 shows that the big tech companies in the US today hold around 4% cash as a share of market capitalisation, compared with 2% in the tech bubble, and while the net debt to equity is the same, the ROE at 44% and average margin at 25% are nearly twice the average in the tech bubble.

Exhibit 12: The current crop of leaders is already very profitable and cash-generative
Next twelve month estimate for Big Tech & last twelve months for Tech Bubble

	Market Weight (%)	Fundamentals			
		Cash as % of Market Cap	Net Debt to Equity	Return on Equity (%)	Net Income Margin (%)
Big Tech					
Apple	7.9%	1.6%	-0.3	137%	25%
Microsoft	6.5%	3.8%	-0.3	30%	35%
Alphabet	4.2%	3.9%	-0.4	24%	24%
Amazon	3.8%	8.3%	-0.1	13%	5%
Nvidia	3.2%	3.4%	-0.5	62%	46%
Tesla	2.1%	4.4%	-0.4	21%	12%
Meta Platforms	1.7%	4.8%	-0.3	22%	28%
Big Tech Aggregate	**29.3%**	**4.3%**	**-0.3**	**44%**	**25%**
Tech Bubble					
Microsoft	4.5%	3.0%	-0.6	35%	39%
Cisco Systems	4.2%	0.9%	-0.2	22%	17%
Intel	3.6%	7.7%	-0.3	26%	25%
Oracle	1.9%	0.8%	-0.6	39%	15%
IBM	1.7%	2.7%	1.1	39%	9%
Lucent	1.6%	0.9%	0.4	36%	9%
Nortel Networks	1.5%	1.1%	0.0	-1%	-1%
Tech Bubble Aggregate	**19.0%**	**2.4%**	**0.0**	**28%**	**16%**

Source: Datastream, FactSet, Goldman Sachs Global Investment Research

This has made these companies relatively defensive in terms of their revenues and earnings. As Exhibit 13 shows, the Big Tech companies have generated roughly 3x the average sales growth of the market and 2x the net income margin. High reinvestment rates and network effects are likely to make these companies defensive stable growth opportunities that can generate high compounding returns.

Exhibit 13: Big Tech companies have consistently delivered superior top- and bottom-line growth in recent years

	y/y Sales growth								
	2015	2016	2017	2018	2019	2020	2021	2022	2023E
Big Tech	16%	9%	19%	25%	13%	22%	28%	9%	9%
S&P 500 ex. Big Tech	-4%	3%	6%	8%	3%	-2%	16%	11%	2%

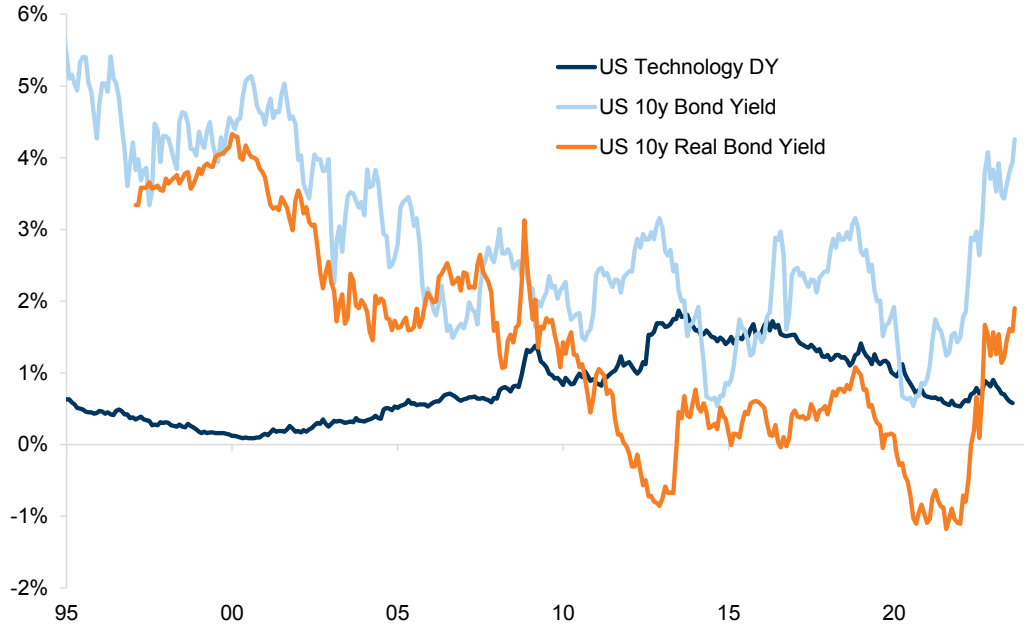
	Net Income margin								
	2015	2016	2017	2018	2019	2020	2021	2022	2023E
Big Tech	12%	15%	15%	15%	21%	18%	22%	22%	25%
S&P 500 ex. Big Tech	10%	10%	11%	12%	12%	10%	13%	12%	12%

Source: Datastream, FactSet, Goldman Sachs Global Investment Research

Another interesting perspective on technology valuation is that it is far less extreme in the current environment relative to other asset classes. For example, Exhibit 14 below shows the dividend yield of the technology sector in the US relative to the yield on US 10-year bonds and on 10-year real bond yields. The dividend yield has fallen from its highs during the pandemic and is now lower than the nominal bond yield and the real yield for the first time since before the financial crisis. Investors are buying equities yielding just 1% despite being offered around 4% on 10-year treasuries and close to 2% in real terms. Nevertheless, during the optimism of 2000, investors were giving up a nominal bond yield of close to 5% and a real yield of around 4% to buy equities offering virtually no yield at all. This reflects the extreme confidence that investors then had in

the ability of technology companies to offer higher returns even as the risk free returns were highly attractive.

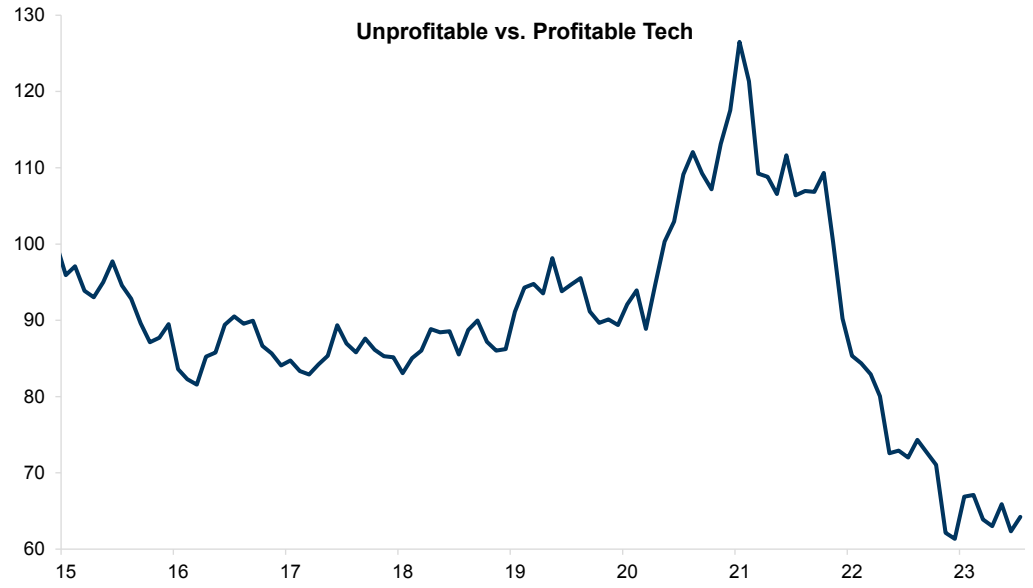
Exhibit 14: Investors are buying equities yielding just 1% despite being offered around 4% in 10-year treasuries
US Technology dividend yield and bond yields in the US



Source: FactSet, Datastream, Goldman Sachs Global Investment Research

Another important point to make about the current focus of investor attention is that it has mainly been reflected in rising valuations for profitable technology companies rather than unprofitable ones (Exhibit 15). This is an import difference to the period prior to the current interest rate cycle when unprofitable technology with high expected growth performed well and enjoyed very high valuations. Many of these companies have de-rated significantly over the past 18 months or so as the higher cost of capital has aggressively undermined their business models and valuations. The biggest profitable tech companies, however, have benefited both from less competition and from their strong balance sheets and cash flow generation, which has made them increasingly defensive on a relative basis under the weight of higher interest rates.

Exhibit 15: The higher cost of capital has aggressively undermined unprofitable tech's business models and valuations
Unprofitable vs. Profitable Tech. Indexed relative performance



Source: Goldman Sachs Global Investment Research

So, where are we in the life cycle of new technologies?

From the history mentioned above, we can summarise the typical life cycle of the technology sector in the stock market as being split into four phases:

1: New tech drives strong performance and higher valuations that are broadly justified by enhanced future profit streams.

2: Exuberance builds, driving ever-higher valuations and lots of new market entrants; eventually valuations reach levels that imply a future market size that cannot be justified for the industry as a whole.

3: The bubble bursts.

4: Many companies disappear, leaving new dominant leaders that drive the technology forward, with its impact reaching the broader economy with a second wave of relative winners and losers.

Given the valuations of the dominant incumbent companies are high but not excessive, we believe we are still generally in the first phase of a typical technology wave. If this is the case, it suggests there will be further emergence of new entrants in the space and still higher valuations in this part of the market. There is a risk that the current enthusiasm leads to a bubble, or to a point where incumbent valuations rise excessively relative to their future growth potential, but we do not think we are at this point yet.

Can technology remain the biggest sector?

The technology sector has already been dominant in terms of market capitalisation (at

least in the US) fairly consistently since the software revolution of the 1980s, interrupted only by a brief period of financials dominance before the financial crisis. However, the history of the sector composition of the S&P 500 as a benchmark suggests that a dominant sector can remain so for extended periods of time. Over time, different waves of technology resulted in different phases of sector dominance; as stock markets have become more diversified, the biggest sector has tended to account for a smaller share of the aggregate market. Nevertheless, the technology sector probably remains the biggest sector in the market (at least in the US) and many new companies are likely to enter the sector as confidence builds and IPOs re-emerge.

We can split the long sweep of history in the US equity market into four main periods of leadership:

- **1800-1850s: Financials**

  Over this period banks were the biggest sector. Starting with almost 100% of the equity market, the stock market developed and broadened out. By the 1850s, the sector's weight had more than halved.

- **1850s-1910s: Transport**

  As banks started to finance the thriving railroad system in the US (and elsewhere for that matter), transport stocks took over as the largest in the index. In their boom years, transport stocks reached close to 70% of the index in the US before fading to around one-third of the market capitalisation by World War 1.

- **1920s-1970s: Energy**

  With the huge growth of industry, powered by oil rather than steam and coal, energy stocks took over as the biggest sector. This remained the main sector group until the 1990s, although interspersed with brief periods of leadership from the emerging technology sector (in the first wave it was led by mainframes and, subsequently, by software).

- **1980s-now: Technology**

  Technology has generally been among the biggest sectors in the US (although not in all other countries) since the emergence of mainframe computing in the 1970s (briefly beaten by the banks sector in the run-up to the financial crisis). Of course, the leaders in the technology space have changed over this period. IBM was the biggest company as mainframes drove the data revolution in the mid-1980s, Microsoft became the biggest company as software became the main driver of technology in the 1990s, and then Apple took over as the biggest company in the 2000s, and it remains so today. There have been cycles, with the run-up to the tech bubble in 2000 and the collapse of tech thereafter. However, technology soon returned as the biggest sector (after a brief period when banks took over as the biggest sector in the run-up to the financial crisis).

Can the current group of dominant technology companies remain leaders?

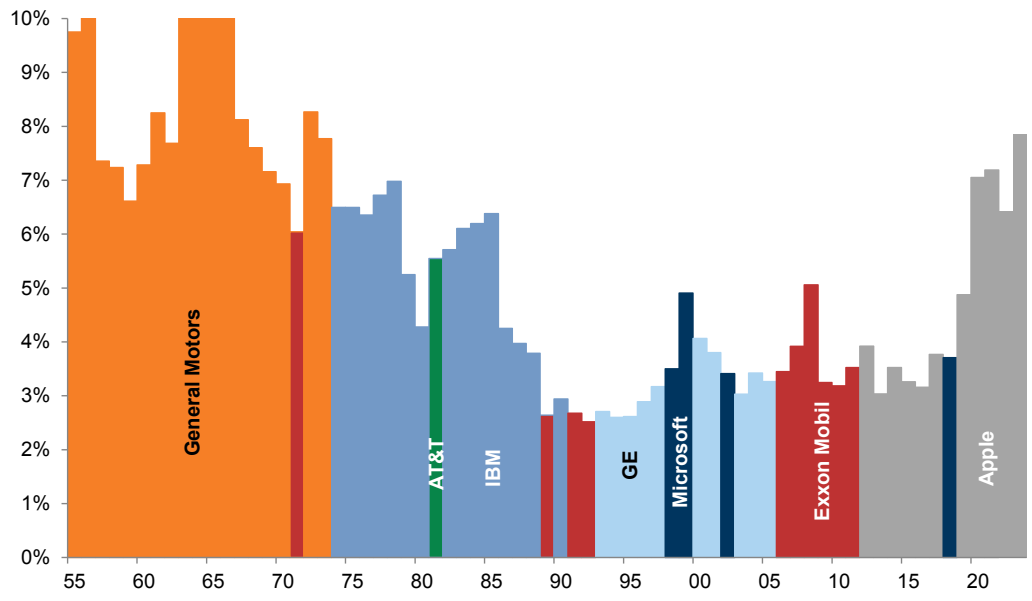
Currently, the concentration of performance in the equity market implies that the leading

incumbents will remain so into the long-term future. However, this pattern of market dominance is not unique to the current revolution in technology: several companies in the past have come to dominate their respective industries on the back of a major innovation or technology cycle. The evolution of the technology sector throughout history tends to show how, ultimately, it can be a 'winner takes all' market:

- Standard Oil, for example, controlled over 90% of oil production in the US by 1900 and 85% of sales.
- Bell Telecom had reached 90% of US households by 1969. Just before it relinquished control of the Bell Operating Companies and was split into different companies in 1982, it reached 5.5% of the market.
- Between 1955 and 1973, General Motors' earnings were more than 10% of the S&P 500. At its peak, General Motors had a 50% market share in the US and was the world's largest automaker from 1931 through to 2007.
- As mainframe computers developed in the 1970s, there was a significant concentration of market share: IBM had over a 60% market share in mainframe computers in 1981.
- As software took over as the main driver of technology, there was yet another shift in domination. By 2000, Microsoft had a 97% share in operating systems given its dominance in the PC and laptop markets.

The largest company in the index has historically belonged to the dominant sector at any time. Typically, it has also tended to maintain its size relative to the market until either regulation (anti-trust) intervenes to reduce market dominance or the incumbent company loses out to a more nimble new entrant with a more cutting-edge technology.

Exhibit 16: The largest company in the index has historically belonged to the dominant sector
% of S&P 500 market cap and % of S&P net income before 1974



Source: Fortune 500, Datastream, Data compiled by Goldman Sachs Global Investment Research

Indeed, it has been common historically for new companies to emerge in the technology sector that challenge incumbents and eventually dominate new products and technologies over time, particularly in the US. For example, just over 10% of the Fortune 500 companies have remained on the list since 1955.

Based on this history, it would appear reasonable to assume the Fortune 500 list in 60 years from now will include very few of the current dominant companies — at least in their current form and structure. A plethora of new companies will be formed in emerging industries we cannot even imagine today. As Exhibit 17 shows, none of the 10 largest companies in the S&P 500 in 1985 were still in the top 10 in 2020, and only one from the list in 2000 remained in the top 10 in 2020.

Exhibit 17: The 10 largest S&P 500 companies through time
By market cap on 31 December

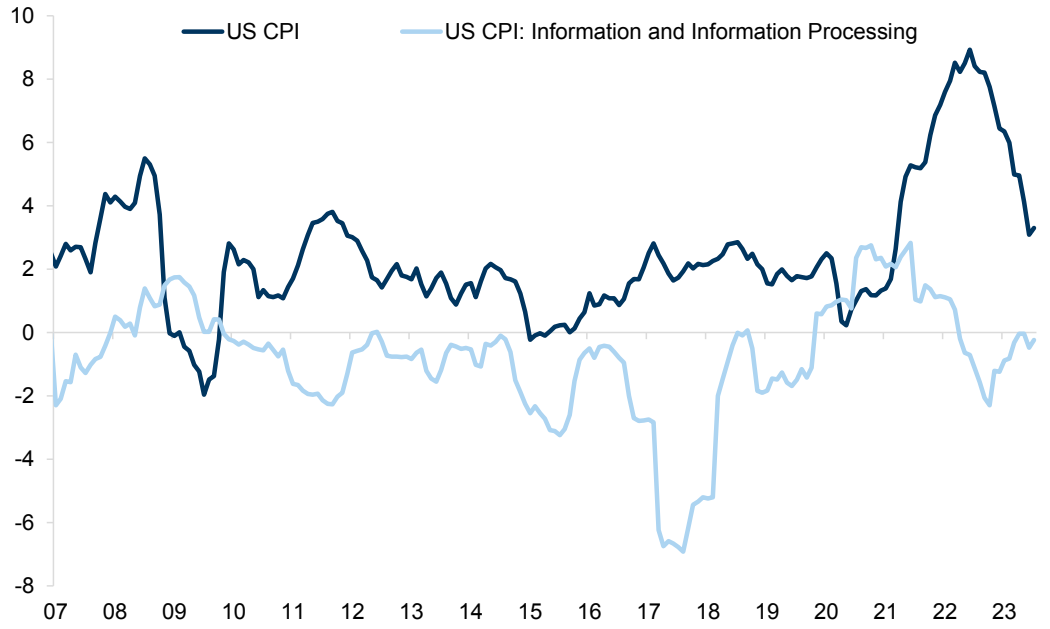
1985		1990		1995		2000	
IBM		IBM	2.9%	General Electric	2.6%	General Electric	4.1%
Exxon Mobil		Exxon Mobil	2.9%	AT & T	2.2%	Exxon Mobil	2.6%
General Electric		General Electric	2.3%	Exxon Mobil	2.2%	Pfizer	2.5%
AT&T		Philip Morris	2.2%	Coca-Cola	2.0%	Cisco Systems	2.4%
General Motors		Royal Dutch Shell	1.9%	Merck & Co	1.8%	Citigroup	2.2%
Amoco		Bristol-Myers Squibb	1.6%	Philip Morris	1.7%	Walmart	2.0%
Royal Dutch Shell		Merck & Co	1.6%	Royal Dutch Shell	1.6%	Microsoft	2.0%
Du Pont		Walmart	1.6%	Procter & Gamble	1.2%	American International (	2.0%
AT & T		AT & T	1.5%	Johnson & Johnson	1.2%	Merck & Co	1.8%
Chevron		Coca-Cola	1.4%	IBM	1.1%	Intel	1.7%
2005		**2010**		**2015**		**2020**	
General Electric	3.3%	Exxon Mobil	3.2%	Apple	3.3%	Apple	6.7%
Exxon Mobil	3.1%	Apple	2.6%	Alphabet	2.5%	Microsoft	5.3%
Citigroup	2.2%	Microsoft	1.8%	Microsoft	2.5%	Amazon.com	4.4%
Microsoft	2.1%	General Electric	1.7%	Exxon Mobil	1.8%	Alphabet	3.3%
Procter & Gamble	1.7%	Chevron	1.6%	General Electric	1.6%	Meta Platforms	2.1%
Bank of America	1.6%	IBM	1.6%	Johnson & Johnson	1.6%	Tesla	1.7%
Johnson & Johnson	1.6%	Procter & Gamble	1.6%	Amazon.com	1.5%	Berkshire Hathaway	1.4%
American International	1.6%	AT&T	1.5%	Wells Fargo	1.4%	Johnson & Johnson	1.3%
Pfizer	1.5%	Johnson & Johnson	1.5%	Berkshire Hathaway	1.4%	JPMorgan Chase	1.2%
Philip Morris	1.4%	JPMorgan Chase	1.5%	JPMorgan Chase	1.4%	Visa	1.2%

Source: American Enterprise Institute, Datastream, Data compiled by Goldman Sachs Global Investment Research

Nevertheless, we see three reasons why dominant tech companies may stay bigger for longer in the current cycle than we might have seen in historical technology cycles:

First, the tech sector is deflationary (Exhibit 18). As long as that is the case, there is no real incentive for politicians to attack it. In this way the tech sector from a policy perspective may be different from others, such as banks, supermarkets or energy companies, where politicians often argue that the benefits (for example of higher interest rates for savers, or lower food and energy prices) are not being passed on to consumers. This does not make technology companies immune from regulation, but it is more likely to come from issues around privacy and use of data, or the impact on mental health, than on pricing.

Exhibit 18: The tech sector is deflationary
US CPI (%, y/y)

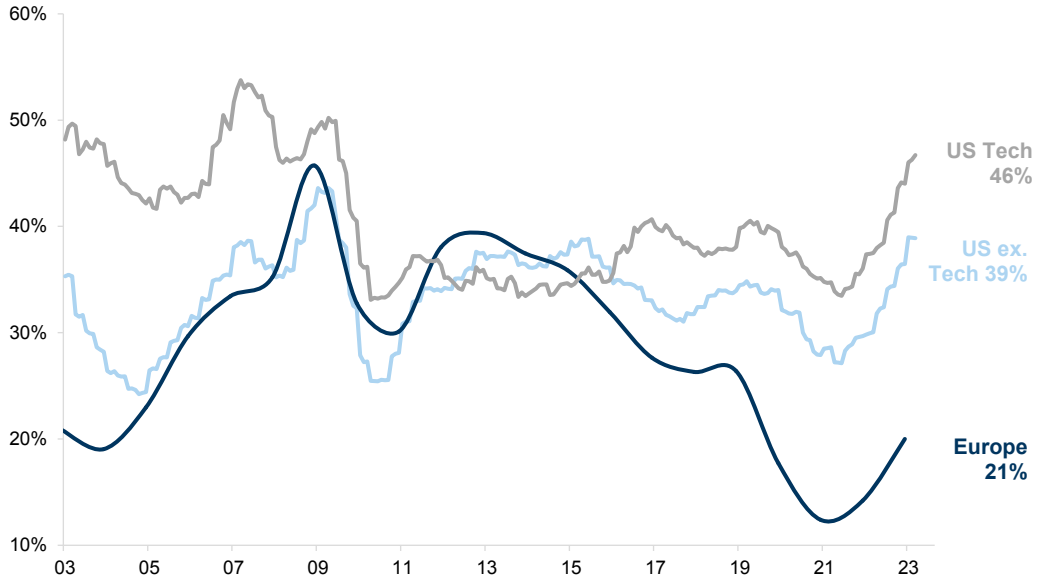


Source: Haver Analytics, Goldman Sachs Global Investment Research

Second, technology is increasingly seen as an issue of national security. Technology, including cyber security, chips and increasingly AI, are seen as a critical part of national infrastructure and strategic defence. This has become more important as geopolitical tensions rise across the world.

Third, the technology sector invests hugely in R&D. Given that the current incumbent winners are so cash-generative, they have an ability to maintain this investment, strengthening their market 'moat' and also potential future growth. According to Erik Brynjolfsson, the top 10% of firms by market value account for over 60% of this intangible digital investment (see Top of Mind: The post-pandemic future of work, 29 July 2021). "They're pulling further away from firms at the median and bottom, so that inequality is growing over time. That's leading to a 'winner-take-most' outcome in which superstar firms are harvesting most of the gains from new technologies rather than those insights diffusing evenly throughout the economy. And that's also happening at the level of individuals and workers — the labour share of income has fallen in recent decades, and the top 1% is getting ever wealthier as they capture a growing share of total income."

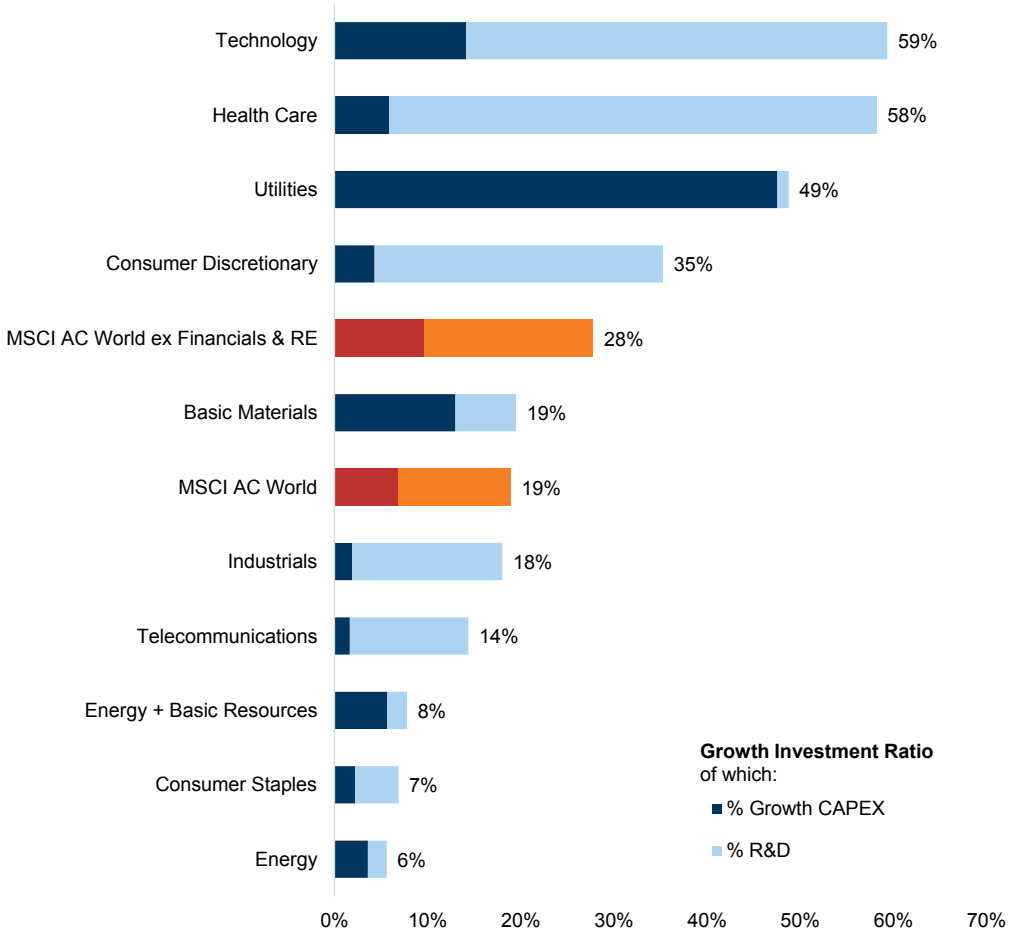
Exhibit 19: Technology sector invests hugely in R&D
Growth Investment Ratio (Growth Capex + R&D / CFO)



Source: FactSet, Goldman Sachs Global Investment Research

As Exhibit 19 shows, the ratio of growth capex (both capex and R&D) as a share of operating cash flow is higher in technology than in any other sector. Microsoft, Alphabet, and Amazon are spending more than $100bn in capex, of which a large portion is on cloud computing and AI, with generative AI likely comprising the fastest-growing category. At the same time, Apple, Meta, and Microsoft each spend around $20bn annually on R&D, while Alphabet and Amazon spend over $25bn and $40bn respectively each year.

Exhibit 20: The ratio of growth capex (both capex and R&D) as a share of operating cash flow is higher in technology than in any other sector globally
Growth Investment Ratio: (Growth Capex + R&D) / Operating Cash Flow. MSCI AC World



Source: Datastream, FactSet, Goldman Sachs Global Investment Research

Technologies and productivity

The impact of technology innovations on productivity is important because it can affect overall economic activity and, by implication, the value of the whole stock market. After years of slow growth, there are some signs of an improvement in productivity emerging from technology that might enhance the growth rates and returns to the markets overall (see the work from our US colleagues). Some academics argue that this could be related in part to one-off effects around the pandemic, but in part also due to a J-curve effect.[3] This is when radical new technologies, such as the internet or AI, require that significant complementary investments be made before their impact can be fully utilised and measured.

There are also good reasons to believe that productivity has been under-measured over

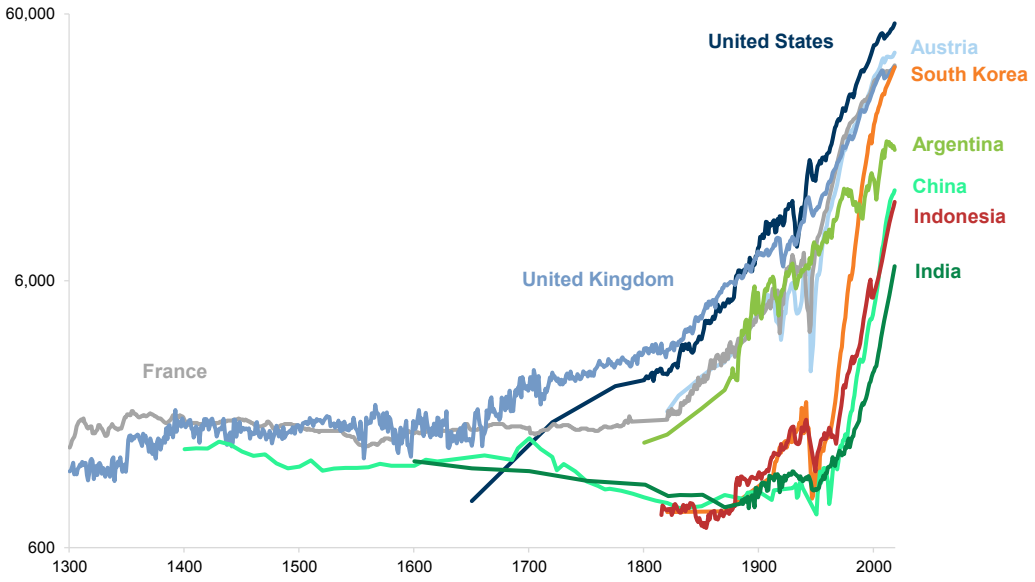
[3] Brynjolfsson, E., Rock D., and Syverson, C. (2021). The Productivity J-Curve: How Intangibles Complement General Purpose Technologies. American Economic Journal: Macroeconomics, 13(1), pp.333-72.

the past couple of decades as the growth of 'free' goods in the economy has been insufficiently measured. Our economists point out that it would require over 10 devices and $3,000 to replicate the most basic functions of today's smartphones, and that missing growth from 'free' digital goods such as Google Maps, camera phones, and Snapchat may be underestimating activity.[4] In an experimental setting, Brynjolfsson et. al (2019) asked consumers to choose between forgoing access to social media or paying a monetary penalty. The dollar values assessed by the median participant imply trillions of unmeasured consumer surplus.

There is compelling evidence from history that previous waves of technology have resulted in slower growth in productivity and economic activity than is generally believed. For example, while James Watt marketed a steam engine in 1774, it took until 1812 for the first commercially successful steam locomotive to appear, and it was not until the 1830s that British output per capita clearly accelerated because the impact of the technologies was subject to network effects. Coal transport eventually provided a major boost to growth and productivity but could not be fully adopted until transport networks were in place. Equally, the large, fixed costs of investment could only be recouped when enough users had switched to the new power source. At the same time, the use of steam power required the construction of factories and the building of canals to facilitate the transportation of raw materials and finished products. In the same way, a transfer of transportation away from the internal combustion engine to electrification may be technically possible but will require an integrated power supply system and re-charging points before it can be fully adopted.

[4] Hatzius, J., Phillips, A., Mericle, D., Hill, S., Struyven, D., Choi, D., Taylor, B., and Walker, R. (2019). Productivity Paradox v2.0: The Price of Free Goods. Goldman Sachs Global Investment Research, US Economics Analyst.

Exhibit 21: Newer technologies have enhanced productivity
GDP per capita adjusted for inflation and price differences between countries. Measured in international $ in 2011 prices. Logarithmic scale



Source: Our World in Data, Goldman Sachs Global Investment Research

A similar pattern can be observed in the electrical age in the 1880s. The innovations in electricity did not yield substantial productivity gains until the 1920s, when the possibilities of factory redesigns were realised.[5] Concerns about the lack of productivity growth and, therefore, the mis-valuation of companies associated with technology were also widespread in the 1980s. In 1987, Nobel Economics Laureate Robert Solow argued that "you can see the computer age everywhere except in the productivity statistics".[6] These concerns faded when many economies saw a dramatic improvement in productivity in the 1990s.

It is possible that a similar effect may be seen after the IT revolution.[7] In this context, it makes sense that the digital revolution has not yet boosted productivity.[8]

Weak productivity from the internet revolution

Productivity growth was disappointing during the last cycle: it averaged +1¼% annually compared with the long-term average of just over 2%. Some have argued that this is a paradox, and that it illustrates the limited impact of such technologies and that stock prices must therefore be overvaluing their potential. But there may be good reasons to be more optimistic about the prospects for productivity growth.

[5] Crafts, N. (2004). Productivity Growth in the Industrial Revolution: A New Growth Accounting Perspective. The Journal of Economic History, 64(2), pp.521-535.

[6] Roach, S. S. (2015). Why is technology not boosting productivity? World Economic Forum.

[7] David, P. A., & Wright, G. (1999). General Purpose Technologies and Surges in Productivity: Historical Reflections on the Future of the ICT Revolution. Economic Challenges of the 21st Century in Historical Perspective.

[8] Mühleisen, M. (2018). The Long and Short of the Digital Revolution. Finance and Development, 55(2).

First, the continuation of moves towards e-commerce and other higher-productivity areas should yield benefits. Second, the digitisation of the workplace and the increased trend towards hybrid (office/home) work may boost productivity by reducing time spent commuting and travelling. Third, the shift towards a higher cost of capital is likely to accelerate the process of 'creative destruction' in technology, with less profitable companies shutting down (as we have seen in previous waves of technology throughout history). Fourth, and perhaps most importantly, while technology in the post-financial-crisis era focused on 'nice to have' products rather than 'need to have' solutions to problems, the next cycle is likely to be driven by solution-focused technologies.

Some of the most significant growth areas over the past 15 years have been in social media, the building of platform companies and the development of apps to facilitate easier transactions. For example, the total number of mobile apps globally has now reached a massive 8.9 million, according to a new report from RiskIQ.[9] Of course, not all of these were developed by new companies: apps have been developed to access existing services. For example, many apps link companies to a digital platform to enable their customers to order an existing product, such as takeaway food. While these are no doubt useful, in many cases the underlying product purchased has not changed. Indeed, the home delivery mechanism (often a bicycle) is arguably no more sophisticated than it was a century ago. Furthermore, according to estimates from Statista, over 60% of all apps downloaded in 2022 were games — not something that tends to boost productivity.[10] The scale of adoption of new technologies is so great that some companies have started to limit the number of emails their employees receive at certain times to relieve stress and enhance productivity.

AI as a boost to productivity in the Post-Modern Cycle

As we move through the Post-Modern Cycle, new major challenges will increase the focus on technology as a solution. In particular, the focus on energy efficiency and decarbonisation should increase investment in technology companies that can enhance efficiency (as opposed to selling consumer products in particular). At the same time, ageing populations and the significant decline in labour participation should incentivise companies to spend more on mechanisation and substitution of labour for technology.

These innovations have two potential impacts. First, on the destruction or displacement of many existing roles and, second, on generating higher productivity and growth and, in turn, boosting real incomes after many years of stagnation. If this becomes a reality, the rise in real incomes will likely spawn a whole host of new sub-industries and job opportunities.

On the point about job destruction, the prospects appear alarming at first sight. Our economists argue that AI could substitute up to one-fourth of current work, or possibly 300 million full-time current jobs, due to automation. That said, we should not become

[9] RiskIQ (2021). Tumultuous Year Bred New Threats, But the App Ecosystem Got Safer. 2020 Mobile App Threat Landscape Report.

[10] Armstrong, M. (2023). Games Dominate Global App Revenue. Statista.

too worried. Worker displacement from automation has usually been offset by the creation of new jobs or industries that are hard to imagine at the time (think of the explosion in the fitness industry or eating out, for example). Most importantly, they argue that the combination of labour-saving costs and higher productivity of the workers who remain in their current roles raises the prospect of a productivity boom that could substantially enhance economic growth — particularly if, in decades to come, the prospect of near-free renewable energy becomes a reality. They estimate that in the US alone, productivity growth could rise by just under 1.5% per year over a 10-year period following widespread adoption. Thus, AI could eventually boost global GDP by 7%.[11]

Supporting this, a recent study shows that, since the advent of deep learning approaches to technology in the 2010s, the training compute (that is, the number of computations used to train AI models) has doubled approximately every six months.[12] This is less than one-third the doubling time implied by Moore's law, which has prevailed for the previous 60 years.[13]

A recent working paper by the US National Bureau of Business Research (NBER) studied the introduction of an AI-based conversational assistant using data from 5,179 customer support agents.[14] They found that access to the tool boosted productivity (measured by issues resolved per hour) by 14% on average. They also found that the greatest positive impact was on new or low-skilled workers — partly because the tool is designed to disseminate the knowledge of more experienced employees to newer workers, enabling them to develop more quickly. They also found that the AI assistant improved customer sentiment and helped to boost employee retention. This is an example of how many productivity benefits from technologies related to AI may also serve non-technology companies, as they can utilise AI tools to boost productivity and efficiency.

Our economists estimate that widespread generative AI adoption (which we assume occurs in 10 years) could boost US productivity growth by 1.5pp annually over a 10-year period and lift trend real GDP growth by 1.1pp for 10 years (see pages 14-15). Under these assumptions in our dividend discount model (DDM), we estimate that S&P 500 EPS CAGR over the next 20 years would be 5.4%, 50bp greater than our current assumption of 4.9%, and S&P 500 fair value would be 9% higher than current levels, holding all else equal.

The PEARLs framework for finding winners

So, is there a way to think about winners and losers in the context of rapid technology innovations? Our suggestion is to think about companies by characteristic using our

[11] Hatzius, J., Briggs, J., Kodnani, D. and Pierdomenico, G. (2023). The Potentially Large Effects of Artificial Intelligence on Economic Growth (Briggs/Kodnani). Goldman Sachs Global Investment Research.

[12] Sevilla, J., Heim, L., Ho, A., Besiroglu, T., Hobbhahn, M., and Villalobos, P. (2022). Compute Trends Across Three Eras of Machine Learning. arXiv.

[13] Moore's law suggests that the number of transistors on a microchip double roughly every two years and, with it, the speed and capability of computers.

[14] Brynjolfsson, E., Li, D., and Raymond, L. (2023). Generative AI at Work. National Bureau of Economic research.

PEARLs framework.

PIONEERS — the early innovators.

ENABLERS — companies that help to facilitate the innovators to commercialise the new technologies.

ADAPTORS — companies in other industries that change their business models to utilise the new technologies.

REFORMERS — the new entrants that re-shape and disrupt other industries by leveraging the technologies to make them more scalable.

LAGGARDS — companies that are slow to change to the new innovations and are either overtaken or competed away.

The Pioneers

The creators tend to benefit first in terms of price appreciation. They are the innovators of the new technology or the companies spending most on developing it and are, generally, the easiest to spot. As we have seen, these companies have enjoyed the greatest outperformance so far, although they remain less highly valued, with stronger cash flows than has generally has been the case in past cycles.

However, while the pioneers may be the easiest to identify early on, they are not always the biggest beneficiaries. Often new entrants emerge that are more nimble and can usurp a dominant incumbent, even if the incumbent remains successful. This was clearly the case, for example, in the internet search engine space. However, secondary innovations often emanate from the original technology, frequently from latter pioneers. These can create significant growth as a whole new product area, or even industry, emerges. While these are, of course, very difficult to spot in the early days of the technology, they can become some of the biggest winners. An example with the internet was the emergence of the smartphone and social media companies.

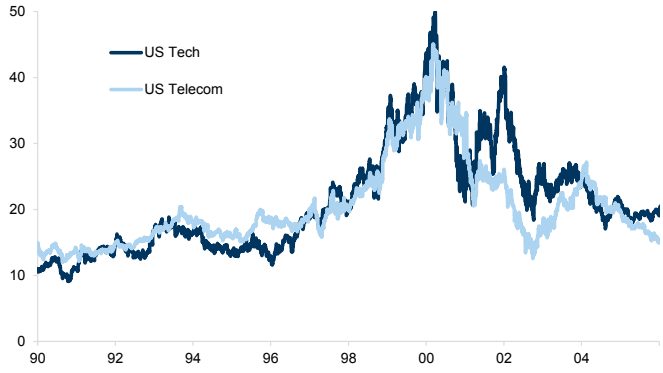
The Enablers

The companies that help facilitate a technology change are vital to its success in commercialising the opportunity. In the current AI wave this includes many of the chip companies essential to the widespread deployment of AI. Like the Pioneers, these enablers are usually easy to spot as the technology scales and becomes commercially viable. However, the longer-term investment implications for these companies are not always straightforward. In the case of the internet revolution, for example, the commercial and scalable use of the internet could not have happened without the telecom companies. These enabled the roll-out of the infrastructure and were the ones investing in the networks; it was assumed that by owning the 'pipes' they would reap many of the rewards which, ultimately, other companies (and consumers) benefited from. However, as they aggressively competed for licences to buy spectrum and bore most of the costs of the infrastructure, they failed to realise an adequate return on investment to justify their inflated valuations at the time.

As Exhibit 22 and Exhibit 23 show, these telecom companies appreciated as much as

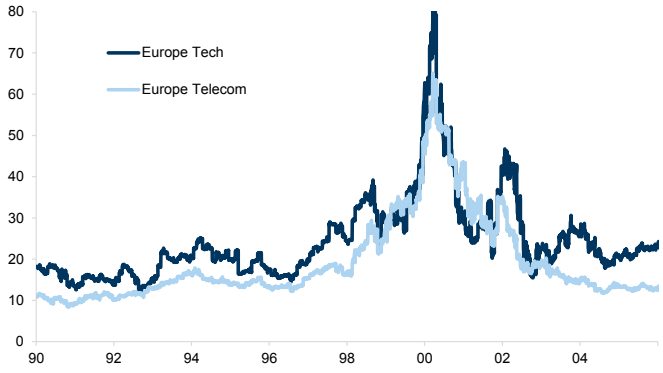
the technology sector over this period and became as expensive, but most failed to earn an adequate return on the investment.

Exhibit 22: Telecom companies appreciated as much as the technology sector during the 2000s...
12m fwd P/E



Source: Datastream, Goldman Sachs Global Investment Research

Exhibit 23: ...even in Europe
12m fwd P/E



Source: Datastream, Goldman Sachs Global Investment Research

Many of the beneficiaries were ultimately not the enablers of the technology but the companies that innovated or adapted to leverage the new technologies as they emerged: for example, innovators in the platform business world that applied new technologies to disrupt existing businesses and gain market share (e.g., ride and taxi apps), or innovators in new app-based businesses that could not exist prior to the internet networks being rolled out.

However, other enablers, such as semi-conductor companies, performed well, and we think can do so in the case of AI. The difference reflects, in large part, the barriers to entry. Most critical is whether the large capital investment often required by these companies can yield an adequate return on investment to justify their valuations.

Our Asia Strategy team have discussed a number of companies that belong in the Enablers category. They have an AEJ Generative AI basket (GSSZAIGC) and three sub-baskets of Hardware (GSSZAIHW), Semiconductor (GSSZAISM) and Applications (GSSZAIAP).

The Adaptors

The adaptors are companies outside of the tech industry that adapt to the impact of the new technology and change their business models. The relative success or otherwise of these companies is also unclear. Our Global Markets colleagues show that companies that can use the tools to improve healthcare and education services, for example, may end up as big winners, together with other companies that can adopt the AI solutions to significantly restructure businesses to reduce costs. Innovators in new business growth areas, such as data and fact-checking, might ultimately thrive. Finally, many of the benefits may accrue to consumers in the form of cheaper new services. If all companies in a mature sector adopt a new technology that makes them more efficient, competitive pressures often mean that the biggest winner is the consumer and, ultimately, companies that build business models to benefit from increased leisure time and higher disposable incomes.

In the end, much will depend on the extent of competition and the quality of the implementation. The majority of companies in most industries moved to adopt PCs, for example, and away from mainframes in the 1980s and 1990s. While these changes increased productivity and reduced costs, this happened across all competitors together. The main beneficiaries in this case were consumers, and this has largely been true in the case of the internet revolution. Most companies outside the technology sector have 'gone on-line', generating greater efficiency and better reach. But since this is true of nearly all companies, competition has led to most of these benefits going to consumers in the form of better services and lower prices. Nonetheless, many industries have seen a dominant winner that has become dominant either because it had additional scale at the outset, or its execution was much better. In the retail space, as an example, most companies have a web presence but, in several countries, a few dominant players have been more successful at developing omni-channel sales and have outperformed over time. Our US colleagues have identified companies with the largest potential long-term EPS boost from the impact of AI adoption on labour productivity (GSTHLTAI). Their analysis suggests that, following widespread AI adoption, EPS for the median stock in the basket could be 72% higher than the baseline, compared with 19% for the median Russell 1000 stock.

The Reformers

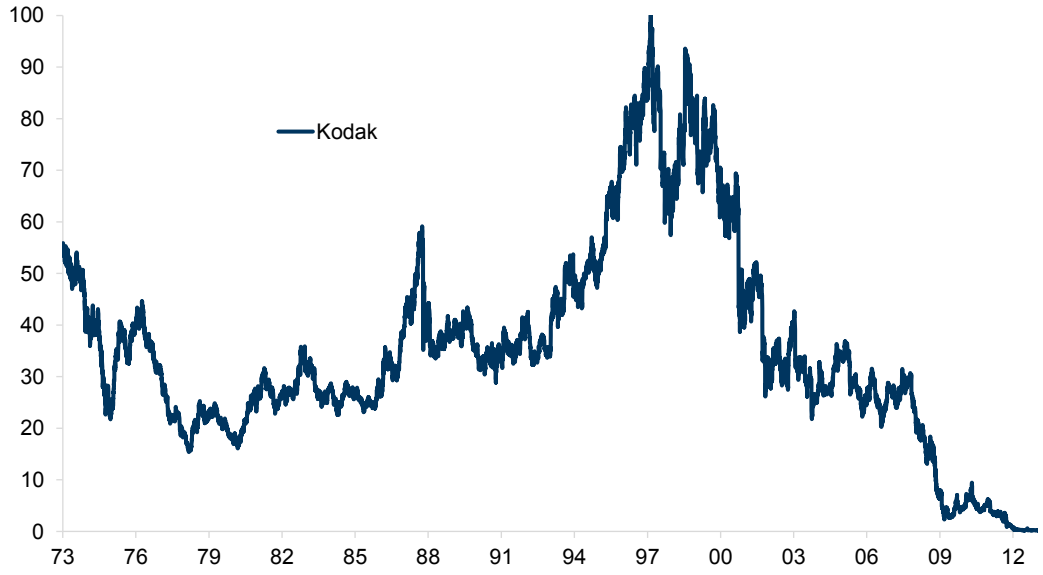
The reformers are typically new market entrants unencumbered by legacy costs. Such companies can disrupt a mature non-technology industry by utilising the innovations to create a new business model that is more scalable than those of existing competitors. Examples would include Amazon in the retail space, car-sharing apps, and online banks. These companies become increasingly valuable as they re-shape the dominant business model and margin dynamics in an industry, and can increase market share at the expense of the incumbents and enjoy strong revenue growth.

The Laggards

These are the companies that are often assumed to be invisible, perhaps because they have a dominant incumbent position in an industry but, for whatever reason, are slow to change and keep up with new innovations. Because these incumbents often have high valuations, they are most at risk from de-rating as they are taken over by more flexible, innovative, competitors. History has many examples of high-profile companies that seemed to have an unassailable lead in their industry but experienced a dramatic demise as they were overtaken by more nimble companies with a better newer technology.

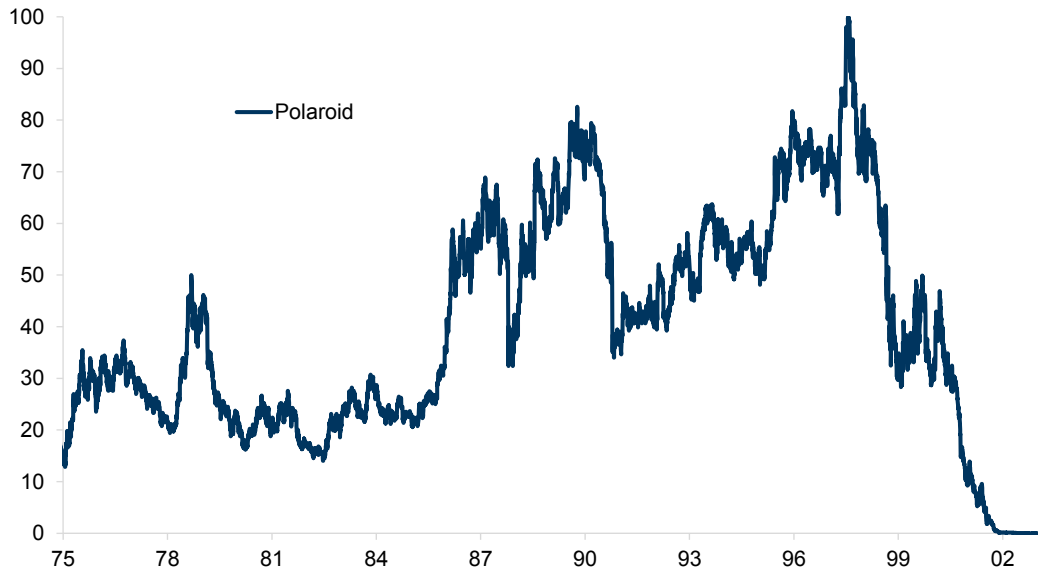
Kodak is a good example. It is said to have invented the first digital camera in 1975 but its engineers failed to obtain approval to launch the product because management was concerned it would negatively impact the film market. Kodak filed for bankruptcy in 2012. A similar fate befell Polaroid. By the 1960s and early 1970s, Polaroid had a monopoly in the instant photography market. It also enjoyed sales of about 20% of the total film market and 15% of the market for cameras in the US. While it did invest in digital technology, it failed to cope with the flood of new entrants in the market and believed that printed copies would always dominate.

Exhibit 24: Kodak invented the first digital camera in 1975 but eventually failed to adapt to new technology
Stock price indexed to its maximum



Source: Datastream, Goldman Sachs Global Investment Research

Exhibit 25: Polaroid had a monopoly in the instant photography market
Stock price indexed to its maximum



Source: Datastream, Goldman Sachs Global Investment Research

Xerox was the first company to invent a PC, but management thought it would be too expensive to commercialise and believed that the future of the company was in copy machines, where it had a 95% market share in the 1970s.[15]

[15] Smith, D. K., and Alexander, R. C. (1999). Fumbling the future: How Xerox invented, then ignored, the first personal computer. iUniverse.

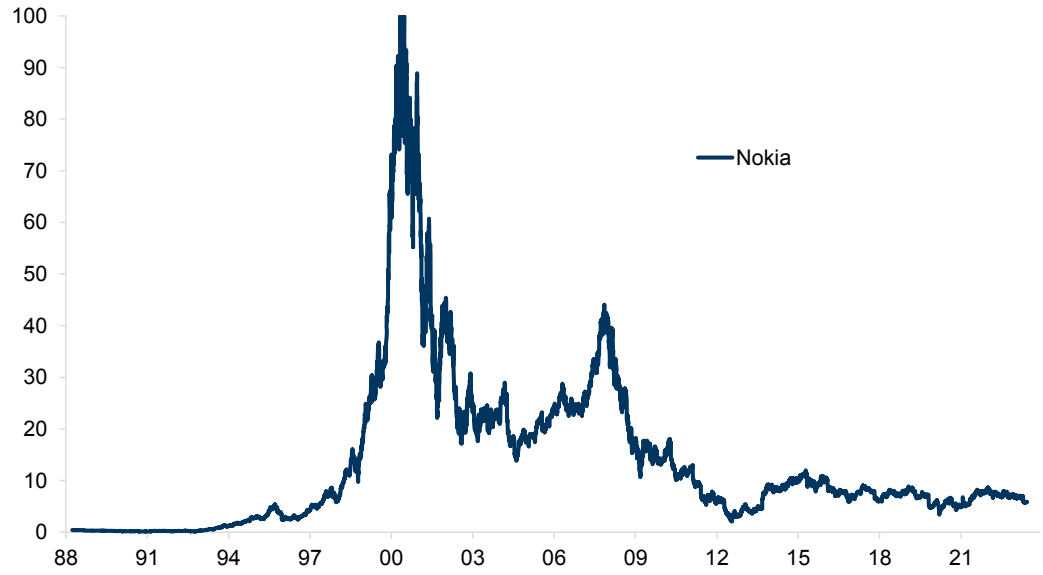
Blockbuster Video was a successful video rental business that navigated the change from VHS to DVD, but not the change to streaming. In 2000, Netflix proposed a partnership with Blockbuster with the idea that Blockbuster would advertise the Netflix brand in their stores and Netflix would run Blockbuster online, but the proposal was turned down. Blockbuster filed for bankruptcy in 2010.[16]

Nokia at one point had over 40% of the world mobile handset market, accounting for 70% of the Finnish stock market and around 4% of Finland's GDP. The company failed to keep up with smartphone technology and eventually sold its handset business to Microsoft in 2013. It then purchased Alcatel-Lucent as it pivoted towards telecommunication infrastructure.

Dell failed to keep up with changing technology and consumer demands. Innovation shifted from the enterprise to consumers, and the dominant computing platforms shifted from the desktop to smartphones and tablets. A proliferation of cloud-based offerings reduced the amount of hardware most companies required, so Dell fell behind companies such as Apple, Amazon and Microsoft.

Nevertheless, some dominant companies that collapse in market value as new entrants and technologies emerge do learn to adapt and shift their businesses. For example, in March 2000, Cisco became one of the most valuable companies in the world with a market cap of over $500 billion, driven by its dominant position in internet protocol, but it eventually saw its share price collapse. Cisco evolved to stay relevant and shifted its business towards services such as online video and data. Similar adjustments occurred with companies such as Microsoft and Ericsson.

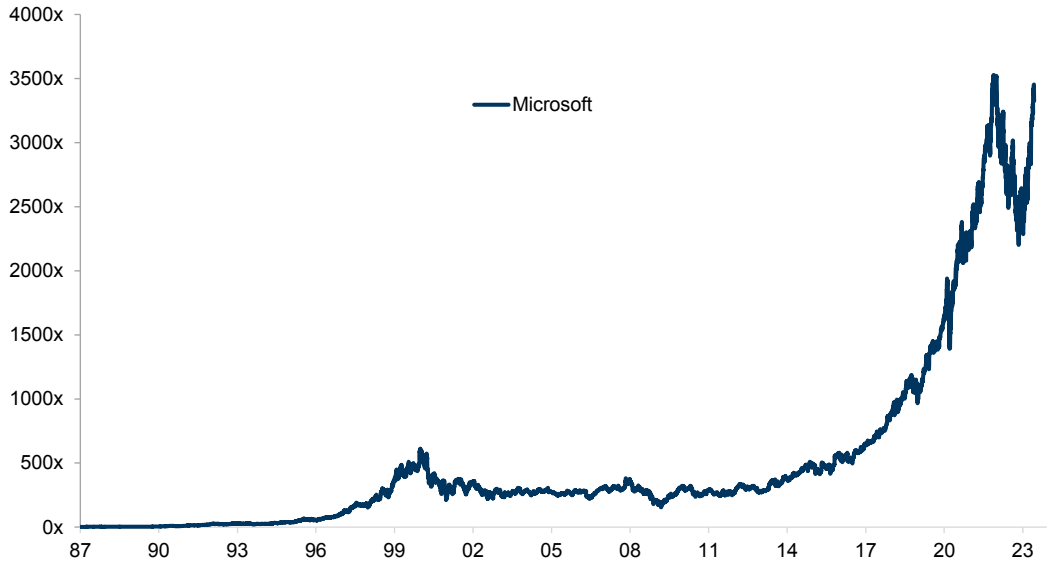
Exhibit 26: Nokia failed to keep up with smartphone technology
Stock price indexed to its maximum



Source: Datastream, Goldman Sachs Global Investment Research

[16] Baskin, J. S. (2013). The Internet Didn't Kill Blockbuster, The Company Did It To Itself. Forbes.

Exhibit 27: Similar adjustments occurred with companies such as Microsoft
Price performance return (1x = 100% gain)



Source: Datastream, Goldman Sachs Global Investment Research

In summary, while the technology sector has once again become dominant in driving relative outperformance, we do not find the valuations similar to other bubble periods. There have already been significant re-ratings of a few companies that can be viewed as 'early winners' — companies that are either the Pioneers in the space or the Enablers. These are likely to continue to perform as the technology scales. Ultimately, the second-wave pioneers that innovate and create new products based on the original technology are also likely to offer exciting investment opportunities. In time, the bigger opportunities may be found in identifying the new Reformers that re-shape industries by leveraging what AI has to offer. Best-in-class Adaptors with industry-leading execution are likely to provide an attractive investment opportunity. However, as many companies adapt to AI, increasing benefits should feed through to consumers. Companies that can tap into this opportunity might benefit more that the market is currently discounting.

Disclosure Appendix

Reg AC

We, Peter Oppenheimer, Guillaume Jaisson, Sharon Bell, Marcus von Scheele and Lilia Peytavin, hereby certify that all of the views expressed in this report accurately reflect our personal views, which have not been influenced by considerations of the firm's business or client relationships.

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Carbonomics

Europe's Energy Crisis

China Agriculture

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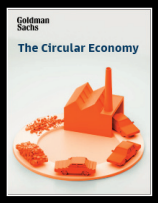


Byte-ology

Gene Editing

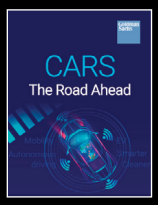
The Metaverse

Cloud Computing

5G

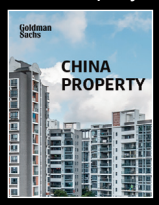
Blockchain

Cars: The Road Ahead

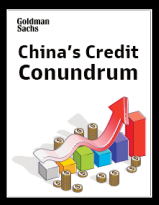


Music in the Air

China Property



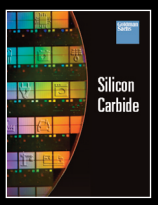
China's Credit Conundrum



Age of Automation

China Post-95s

Silicon Carbide



China Decarbonization

The Survivor's Guide to Disruption

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Inclusive Growth

Market Cycles

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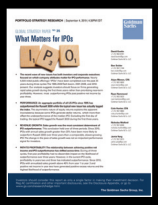
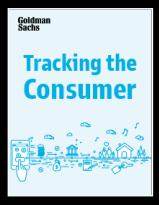
What Matters for IPOs



Top Projects

Tracking the Consumer

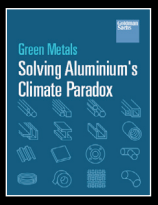


EU Taxonomy

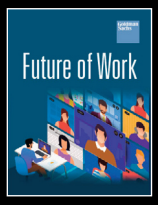
Balanced Bear

Clean Hydrogen

Green Metals



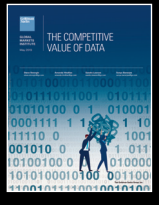
The Future of Work



What the Market Pays For

The Great Reset

The Competitive Value of Data



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