GLOBAL ECONOMICS ANALYST

The AI Spending Boom Is Not Too Big (Briggs)

Jan Hatzius
+1(212)902-0394 | jan.hatzius@gs.com
Goldman Sachs & Co. LLC

Joseph Briggs
+1(212)902-2163 |
joseph.briggs@gs.com
Goldman Sachs & Co. LLC

Sarah Dong
+1(212)357-9741 | sarah.dong@gs.com
Goldman Sachs & Co. LLC

Megan Peters
+44(20)7051-2058 |
megan.l.peters@gs.com
Goldman Sachs International

- Announcements of further increases in an already sizable amount of AI capex spending have amplified concerns around the sustainability of AI investment. In this Global Economics Analyst, we argue that anticipated investment levels are sustainable, although the ultimate AI winners remain less clear.
- The technological backdrop remains supportive of AI capex for two reasons. First, AI applications are boosting productivity when deployed. Second, unlocking these productivity benefits requires significant computational power, especially since models are increasing in size much more quickly than computation and energy costs are falling.
- We are not concerned about the total amount of AI investment. AI investment as a share of US GDP is smaller today (<1%) than in prior large technology cycles (2-5%). Furthermore, we estimate an $8tn present-discounted value for the capital revenue unlocked by AI productivity gains in the US, with plausible estimates ranging from $5tn-$19tn. These estimates exceed current cumulative AI investment forecasts even before considering foreign profits, new profit pools, or the potential of AGI.
- We see valid concerns around whether companies making investment today will benefit from spending, especially since tech hardware depreciates quickly. Timing concerns may be less important if AI investors can capture an outsized share of AI's long-run economic value, but performance of "first movers" has been mixed in prior infrastructure builds, with "fast followers" often leveraging pre-built infrastructure for outsized gains.
- The current AI market structure provides little clarity into whether today's AI leaders will be long-run AI winners. First-mover advantages are stronger when complementary assets (e.g., semiconductors) are scarce and production is vertically integrated—suggesting that today's leaders may outperform—but weaker in periods of rapid technological change like today. First-mover advantages also tend to be stronger when switching costs are high, but early AI adopters are diversifying across multiple models.
- A solid macro story should support AI capex for as long as companies anticipate that 1) a first-mover advantage will allow them to capture an outsized share of AI productivity-related revenues or 2) investments in computational capacity will improve model performance and potentially lead to the emergence of AGI.

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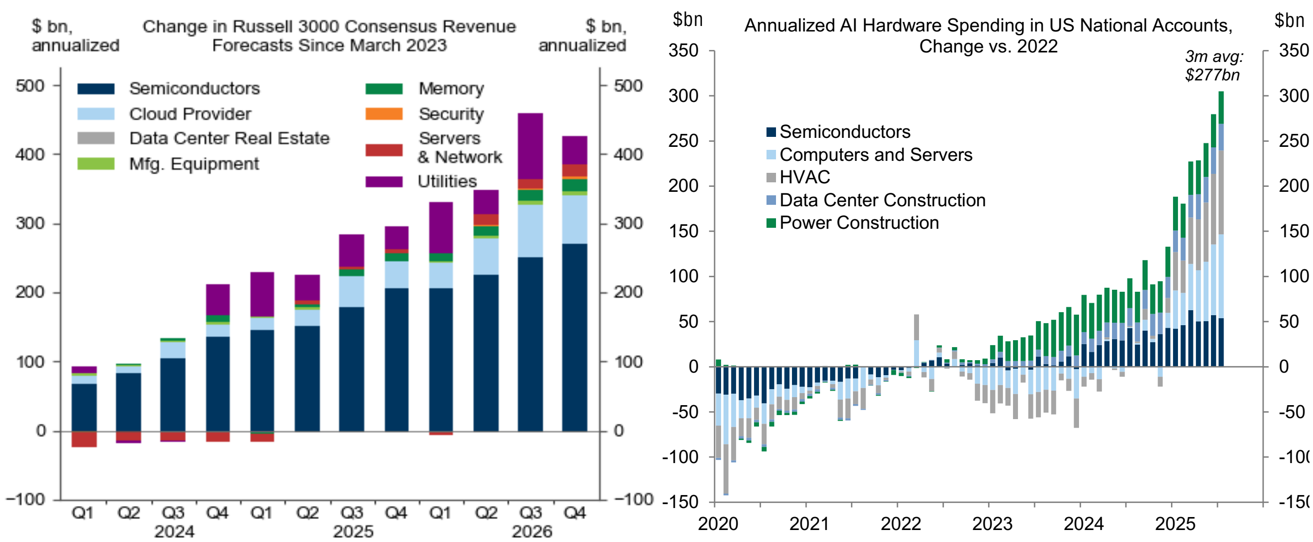
The AI Spending Boom Is Not Too Big

Since the start of September, OpenAI has announced a $300bn deal with Oracle, a $100bn investment from Nvidia, a strategic partnership with AMD to deploy 6GW of GPUs, and a strategic partnership with Broadcom to deploy 10GW of custom AI chips. Other US hyperscalers have also highlighted new investments in 2025H2, albeit at a slower pace.

These investments will add to an already sizable amount of AI capex. As shown in Exhibit 1, revenue increases for public US companies exposed to the buildout of AI infrastructure suggests around $300bn in AI-related spending in 2025, while the three-month annualized pace of AI-related spending in the US national accounts has risen by $277bn relative to its 2022 average. Although the rise in spending over the summer is partially explained by tariff-driven frontloading—US imports from Taiwan drove the recent surge in AI spending but pulled back sharply in September—both measures suggest a large (roughly $300bn annualized) increase in AI-related spending.

Exhibit 1: AI Investment Has Risen by Around $300bn Since 2023



Source: Goldman Sachs Global Investment Research, Compustat, Bureau of Economic Analysis

We have anticipated a large AI investment cycle driven by an initial surge in hardware spend to train AI models and run AI queries since mid-2023, but the size, speed, and circularity of these investment announcements have raised questions around AI capex sustainability (among other issues, see our equity research team's recent summary of key AI debates). These concerns are especially pronounced since AI adoption and revenue remain limited.

Despite these concerns, we continue to see current investment levels as quite sustainable, even though it is less clear whether companies making the investments today will emerge as AI winners.

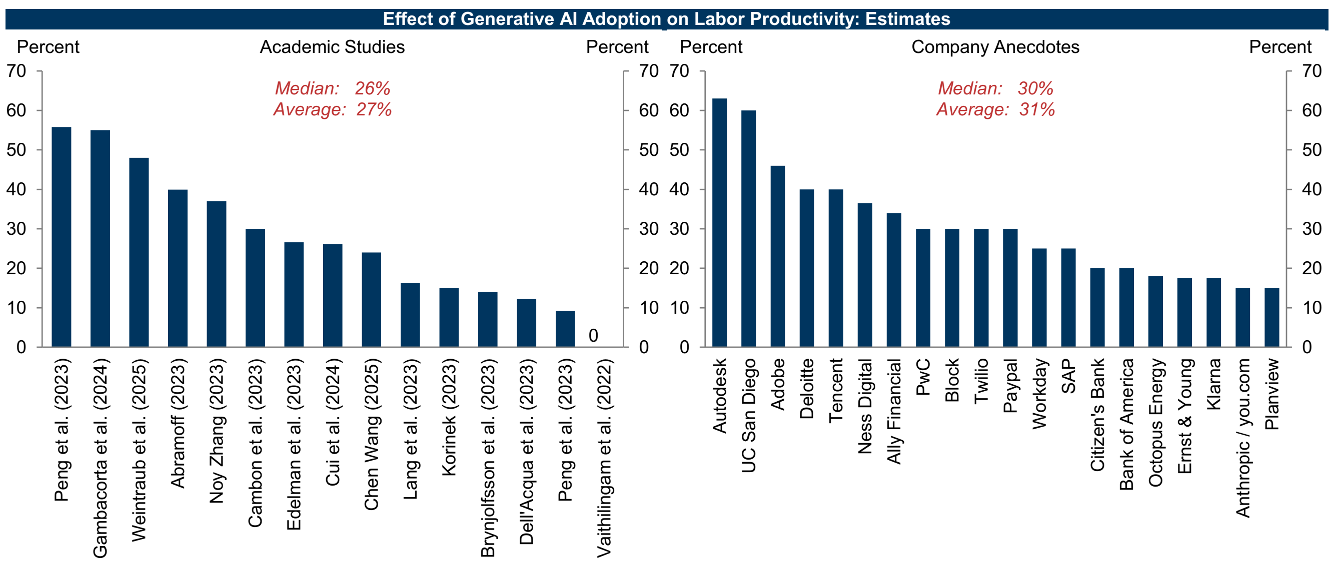
Fundamental Capex Drivers

The technological backdrop remains supportive of AI capex for two reasons.

First, generative AI still appears set to deliver a rapid acceleration in task automation that will drive labor cost savings and boost productivity, with our baseline estimates suggesting a 15% gross uplift to economy-wide US labor productivity following full adoption, which we expect will realize over a 10-year period.

Consistent with our baseline, academic studies and company anecdotes point to 25-30% average productivity gains following the deployment of AI applications. The use cases summarized in Exhibit 2 are admittedly still limited—we estimate that only 2.5% of employment is at risk of automation from current applications, which primarily focus on coding, customer service, and consulting support—and the average impact will likely moderate as applications broaden to job functions that are harder to automate. But these early estimates highlight the potential for generative AI to deliver transformative productivity uplifts when appropriately deployed.

Exhibit 2: AI Drives Large Productivity Gains When Successfully Deployed



Source: Goldman Sachs Global Investment Research

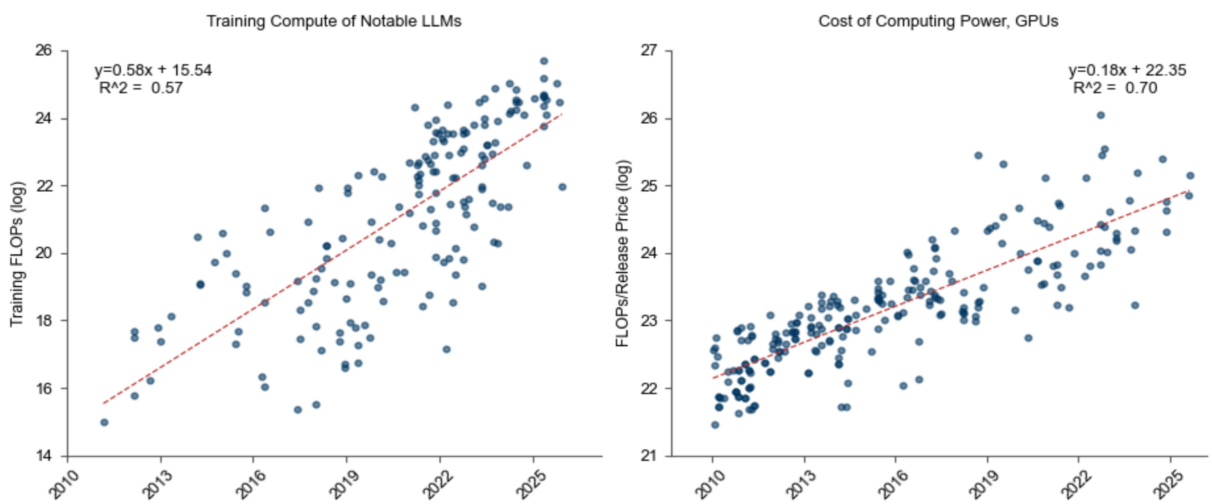
Recent headlines have called into question whether generative AI can drive significant value. Most notably, MIT Media Lab/Project NANDA released a report in August flagging that 95% of AI pilot programs had failed to deliver measurable business value, while only 5% of custom enterprise AI tools had reached production.

We see the details of the MIT study as less concerning for two reasons. First, the key takeaway that only 5% of AI tools had reached the production stage is similar to our tracking estimate from the Census Business Trends and Outlook survey that less 10% of US businesses have adopted AI for regular production. Second, the study also concluded that businesses derived significant value when they 1) bought applications rather than built tools in house, 2) sourced AI automation projects from frontline managers rather than central labs, and 3) targeted automation of specific tasks with integrated tools rather than generic AI applications. Our overall takeaway is that effective AI adoption may take time as companies figure out how to incorporate specific applications into business processes but that AI can deliver sizable productivity gains once this occurs.

Second, unlocking these productivity gains requires significant computational power (and associated energy consumption). Recent trends suggest that computation and energy demands will increase (see our equity analysts' recently updated data center projections, which imply healthy supply/demand growth in the medium term).

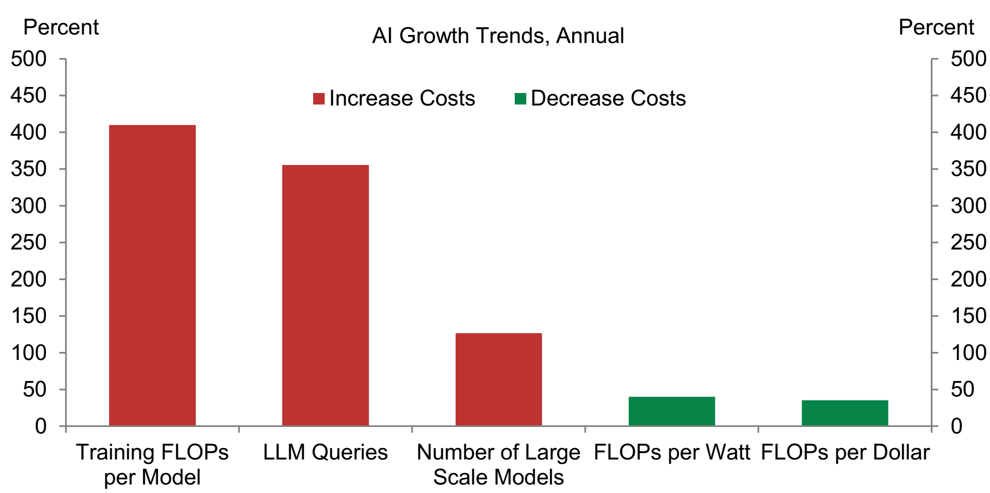
As shown in Exhibit 3, the computational power (measured in floating-point operations, or FLOPs) necessary to train large language models continues to grow at a much faster pace (roughly 400% per year) than computational costs are falling (FLOPs/dollar; decreasing at a 40% per year pace). Exhibit 4 shows a similarly fast pace of demand growth in training queries (350%) and frontier AI models (125%), with energy efficiency improving at a pace that is fast in absolute but slow in relative terms (40%). The punchline from these trends is that investment in computation and power capacity should increase as long as the differential between demand growth and computing cost declines remains wide.

Exhibit 3: Computational Demands of Large Language Models Continues to Grow, While Costs Continue to Fall



Source: Goldman Sachs Global Investment Research, Epoch AI

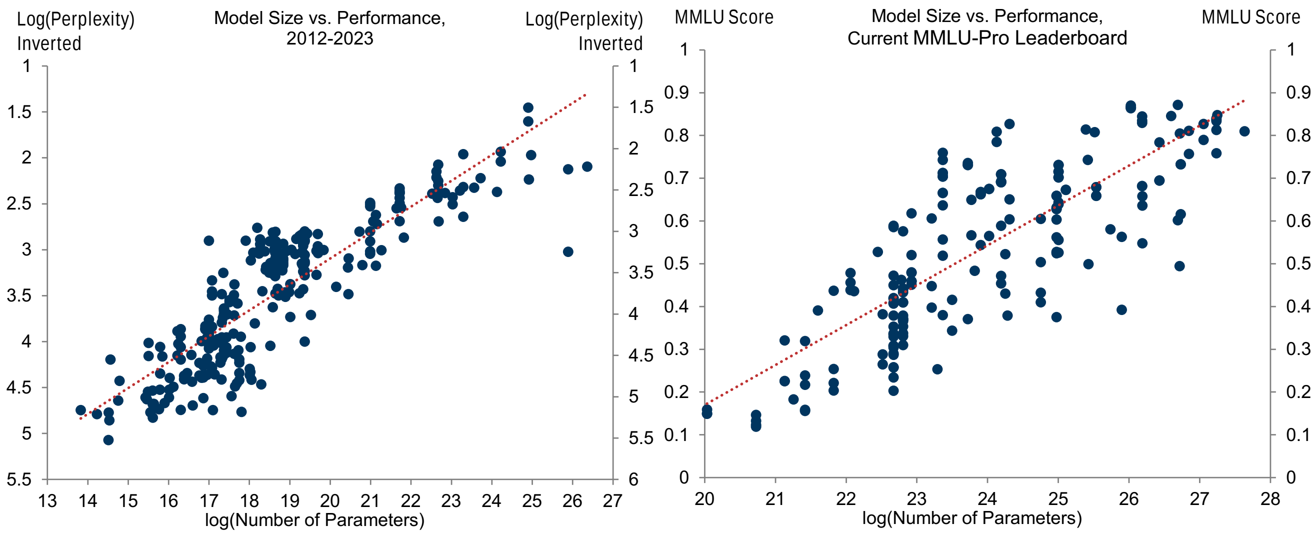
Exhibit 4: Models and Computational Demands Are Currently Growing Much Faster Than Cost or Energy Efficiencies



Source: Goldman Sachs Global Investment Research, Epoch AI

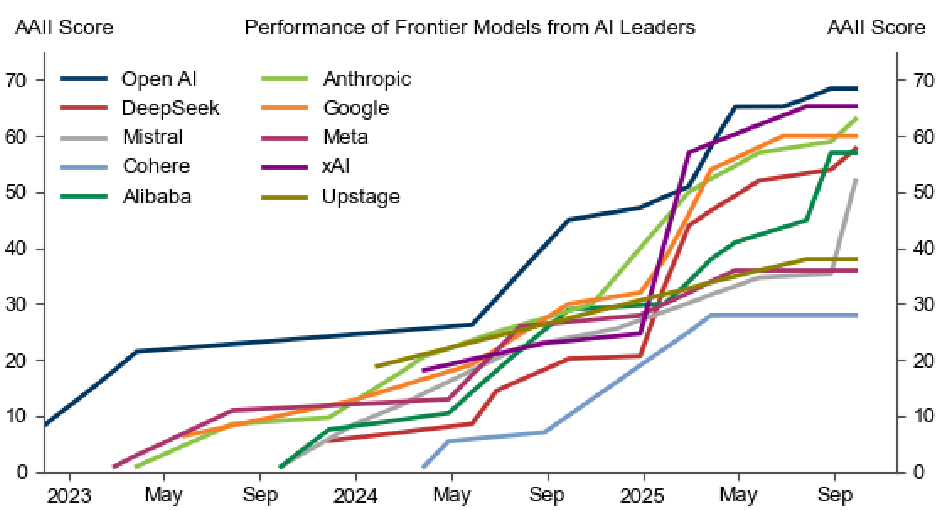
Demand growth will likely continue to outpace technological cost declines in the near term, partly because larger models continue to drive performance improvements. As shown in Exhibit 5, a positive historical correlation between model size and performance (left chart) has continued through the present according to data from the current Hugging Face MMLU-Pro leaderboard (right chart). This pattern suggests continued spending increases by frontier model developers will be necessary to remain competitive (Exhibit 6).

Exhibit 5: Larger Models Are Still Leading to Improved Performance



Source: Goldman Sachs Global Investment Research, Epoch AI

Exhibit 6: Model Performance Has Continued to Improve



Performance of Frontier Models on the Artificial Analysis Intelligence Index

Source: Goldman Sachs Global Investment Research, Hugginface.co

It is hard to know at what point the technological incentives to invest will diminish, but the combination of promising early productivity uplifts and continued improvements in model performance from increased computational resources suggest we are not at that point yet. So while investment should eventually moderate as the AI investment cycle moves beyond the build phase and declining hardware costs dominate, the technological backdrop still looks supportive for continued AI investment.

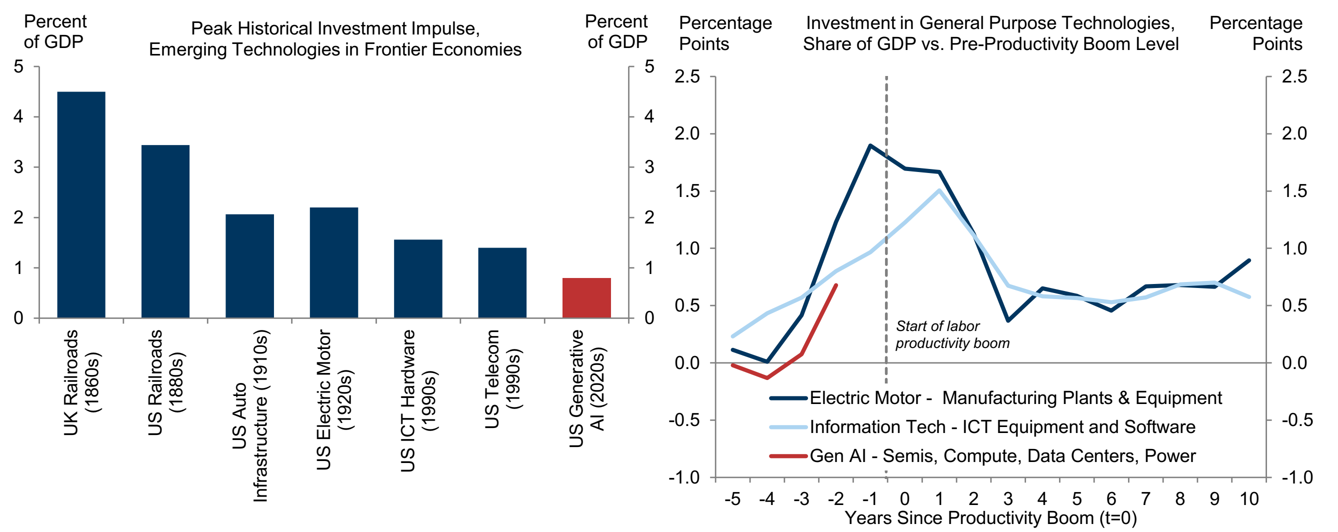
Sizing the Macroeconomic Value of Generative AI

We also still see the macroeconomic justification for AI investment as compelling and are less concerned about the dollar amount of AI capex.

Economic commentators have flagged the unprecedented amount of AI capex currently being deployed, with the cumulative AI-driven datacenter and infrastructure buildout likely to cumulatively total multi-trillions of dollars. For example, Nvidia CEO Jensen Huang highlighted in September that AI infrastructure spend could total \$3-\$4 trillion by 2030. Our equity analysts similarly project sizable investments, particularly in datacenters and power, with hyperscaler capex alone projected to total \$1.4tn cumulatively in 2025-2027.

While the AI investment buildout is admittedly larger than prior cycles in nominal dollar terms, the buildout looks less extreme when appropriately scaled. As summarized in Exhibit 7, historical infrastructure investment impulses have generally peaked at 2-5% of GDP, while investment cycles during the electrification of manufacturing in the 1920s and IT boom in the late 1990s (that motivated our projection in mid-2023 that an AI investment cycle could reach 2% of GDP) peaked at around 1.5-2% of GDP. AI investment in the US over the last 12 months (right chart, Exhibit 7) remains below 1% of GDP, a large but not outsized impulse by historical standards.

Exhibit 7: Large Investment Cycles Have Preceded Prior General Purpose Technology Productivity Booms



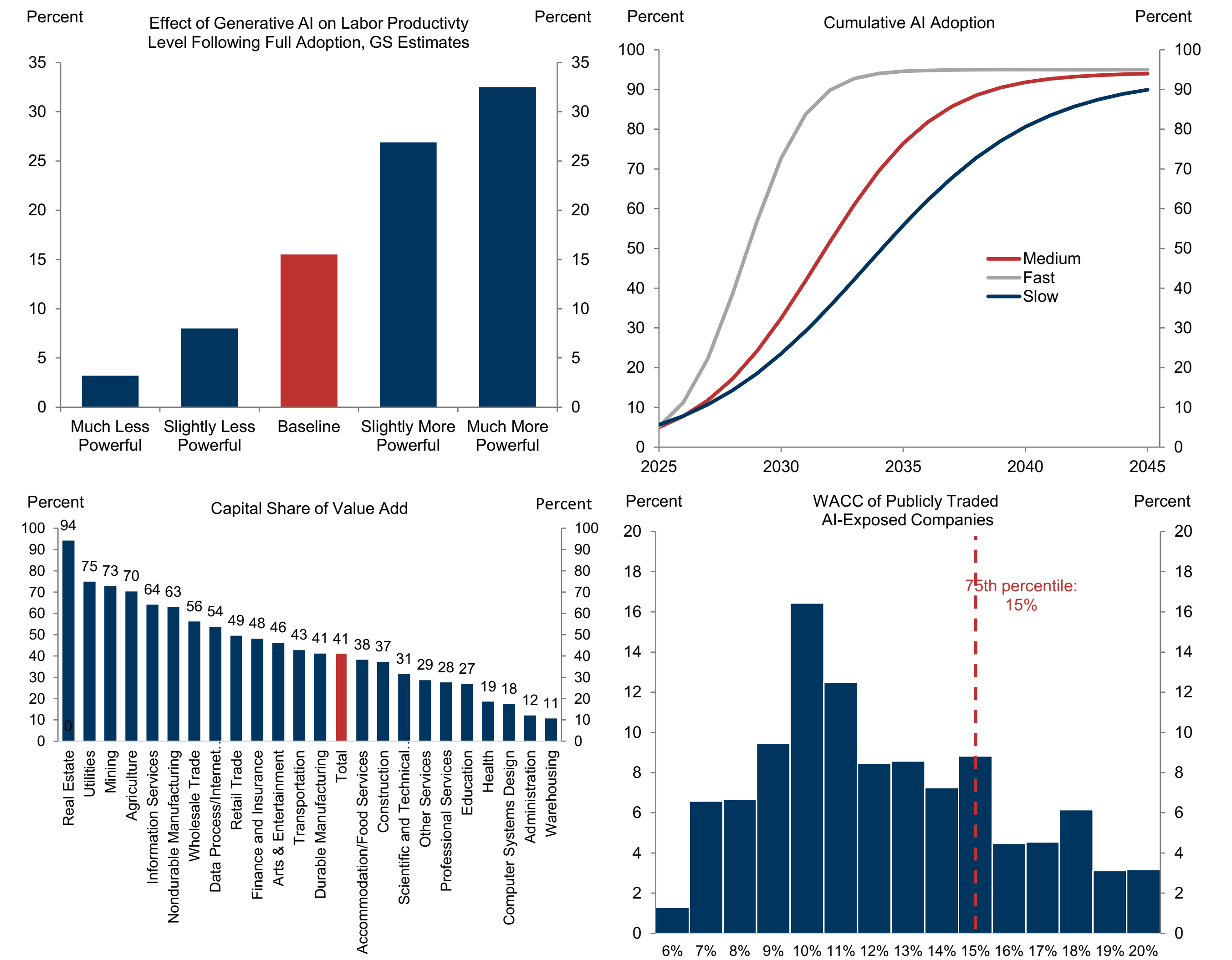
Source: Goldman Sachs Global Investment Research, Bureau of Economic Analysis

More importantly, we believe that the potential economic gains promised by generative AI justify a muti-trillion dollar investment cycle. To estimate the value of future AI revenues, we estimate a present-discounted value (PDV) based on assumptions summarized in Exhibit 7.

- **Productivity:** Based on our AI productivity estimates, we assume a baseline gross 15% uplift to US labor productivity and GDP following full adoption, equivalent to \$4½tn in economic value creation in today's dollars. In alternative scenarios we consider our previous estimates of a "less powerful" AI scenario based on more pessimistic assumptions regarding AI's ability to automate work tasks (implying an 8% productivity uplift) and a "more powerful" scenario where the productivity gains reach 27%.

- **Timeline:** Based on the AI adoption timelines built into our potential GDP forecasts, we assume that company-level adoption mostly takes place over a 10-year period from 2027-2037, with a four-year intra-firm lag between adoption and full realization of the productivity gains. We also consider upside and downside scenarios where AI adoption takes place over 5 and 15 years, respectively.
- **Capital share of AI value-add:** We assume a 41% capital share of the incremental value add created by AI-driven productivity gains, in line with the economy-wide average. We also consider scenarios where the capital share of AI economic value creation corresponds to the 25th (28%) and 75th (60%) percentiles of the capital share across industries.
- **Discount rate:** We assume a discount rate of 15%, corresponding to the 75th percentile of the weighted average cost of capital (WACC) for publicly traded AI companies (measures from Bloomberg). We use the 75th percentile rather than the average (13%) or median (12%) because AI revenues are highly uncertain and because the cost of capital for private AI-exposed companies is likely higher than for their public counterparts. We also consider scenarios with a 5pp higher (20%) and lower (10%) discount rate.

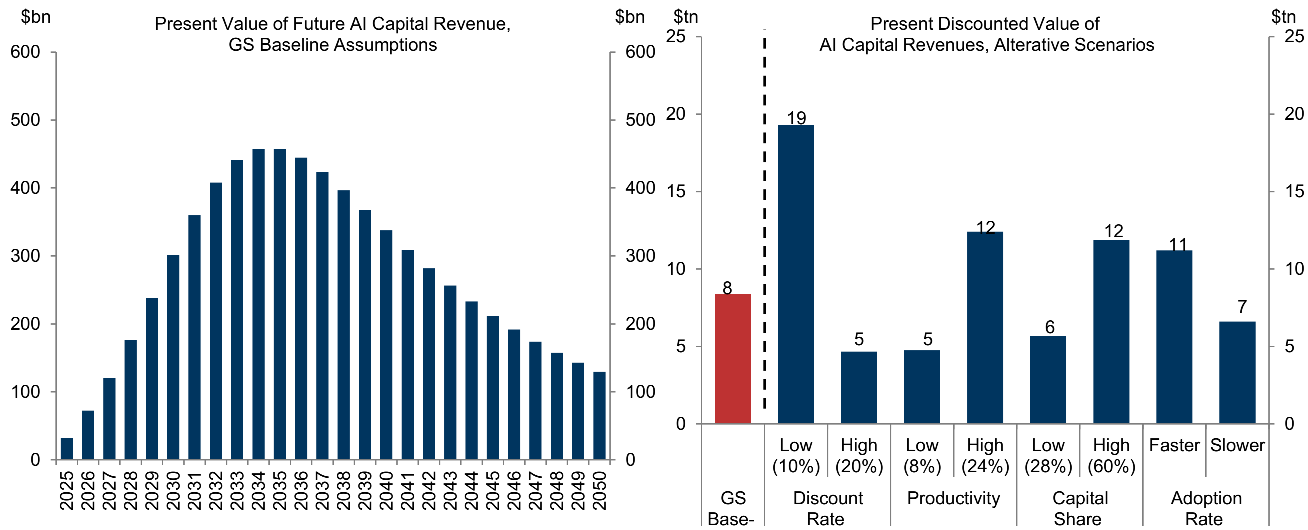
Exhibit 8: Our Baseline Assumptions Assume a 15% Uplift to Productivity, Relatively Slow Adoption Timeline, 41% Capital Share of Output, and 15% Discount Rate



Source: Haver Analytics, Goldman Sachs Global Investment Research, Bloomberg

Under these baseline assumptions, we estimate a $20tn PDV for the economic value created by generative AI in the US, of which $8tn will flow to US companies as capital revenues. Furthermore, we estimate PDV of capital revenues ranging from $5-19tn under the alternative scenarios, with estimates unsurprisingly particularly sensitive to the choice of discount rate (Exhibit 9).

Exhibit 9: The Expected Present Discounted Value of Capital Revenue from AI Exceeds Capex Projections



Source: Goldman Sachs Global Investment Research

Our key takeaway from this exercise is that the PDV of generative AI capital revenue exceeds projections of AI-related capex both under our baseline and alternative assumptions, suggesting that current and anticipated overall total levels of AI capex are more than justified. Furthermore, we reach this conclusion without factoring potential foreign profits, new profit pools, and the emergence of AGI, suggesting a meaningful cushion to the AI infrastructure spending outlook.

Market Structure and Distribution of Rents

While the macro backdrop still looks solid, we see valid concerns around whether companies making investment today will benefit from this spending, however. Whether investing companies will be long-run beneficiaries will depend critically on the timing and distribution of revenues across the AI stack.

On timing, investment in semiconductors and servers—which account for $112bn of the $240bn in AI spend in the US national accounts (right chart, Exhibit 9)—will depreciate quickly given the rapid improvements in computing hardware. Assuming a 5-year lifespan for tech equipment (based on our equity research team's assumptions) and using the BEA's depreciation estimates for HVAC, data center structures, and power investment, we estimate an 18% depreciation rate for current AI capex, raising some potential for mismatch between the timing of infrastructure build and revenue realization.

Timing considerations may be less important if AI investors are able to capture an outsized share of the long-run value, but "first movers" have shown mixed performance in prior infrastructure builds. In Exhibit 10 we qualitatively summarize the ultimate beneficiaries of historical infrastructure investment cycles based on our review of academic research. Three patterns stand out.

First—as was the case for UK canals in the late 1700s and early 1800s, US IT investment in 1980s and 1990s, and (in some cases) for US railroads in the 1800s—first movers commanded outsized returns due to high investment and switching costs. Second, in many cases—e.g., the buildout of UK railroads in the 1800s and more recent buildout of fiber-optic cables and US telecom—first-mover returns were quite poor, as an initial overbuild gave way to a subsequent bust that allowed “fast followers” to capture outsized returns by purchasing assets at low valuations. Third, in other cases—namely the development of UK turnpikes in the 1700s and US electricity in the early 1900s—first-mover returns were limited by regulation and the reorganization of capital as public utilities that limited returns.

Our takeaway from these historical precedents is that the ultimate winners from infrastructure builds are determined by a complex set of factors including timing, regulation, and market competition.

Exhibit 10: First Movers Have Shown Mixed Performance in Prior Infrastructure Builds

Historical Episode	First Mover Returns	Fast Follower Returns	Explanation
UK Turnpikes	Neither abnormally high or low	Neither abnormally high or low	Regulation limited returns.
UK Canals	High	Low	Investment valuable for first movers; Introduction of railroads limited returns to later entrants.
UK Railways	Low	High	Post-bust consolidators were able to purchase assets at low valuations, long-run value creation drove healthy returns for companies that bought railroads at deep discounts.
US Railroads	Mixed	High	In some cases early movers were able to capture outsized returns via local monopoly (e.g., Pennsylvania Railroad became the world's largest corporations), but others had negative returns (half of all railroad mileage built before 1870 went bankrupt or reorganized). Later consolidators (e.g. NY Central, Union Pacific) were able to generate outsized return via purchases at low valuations.
US Electricity	Neither abnormally high or low	Neither abnormally high or low	First movers kept market share, but regulation and organization as utilities limited returns.
US IT	High	High	First movers were able to grab market share in mainframes (IBM), operating systems (Microsoft), networking (Cisco), and cloud computing (AWS), although the late 1990s saw overexuberance and overinvestment. Later entrants also fared well in many areas given transformative effect of tech on economy.
Global Fiber-Optic Cables	Low	High	Overbuild led to low returns for first movers, later buyers captured financial upside by purchasing assets at low valuations.
US Telecom	Low	High	Overbuild led to low returns for first movers, later buyers captured financial upside by purchasing assets at low valuations.

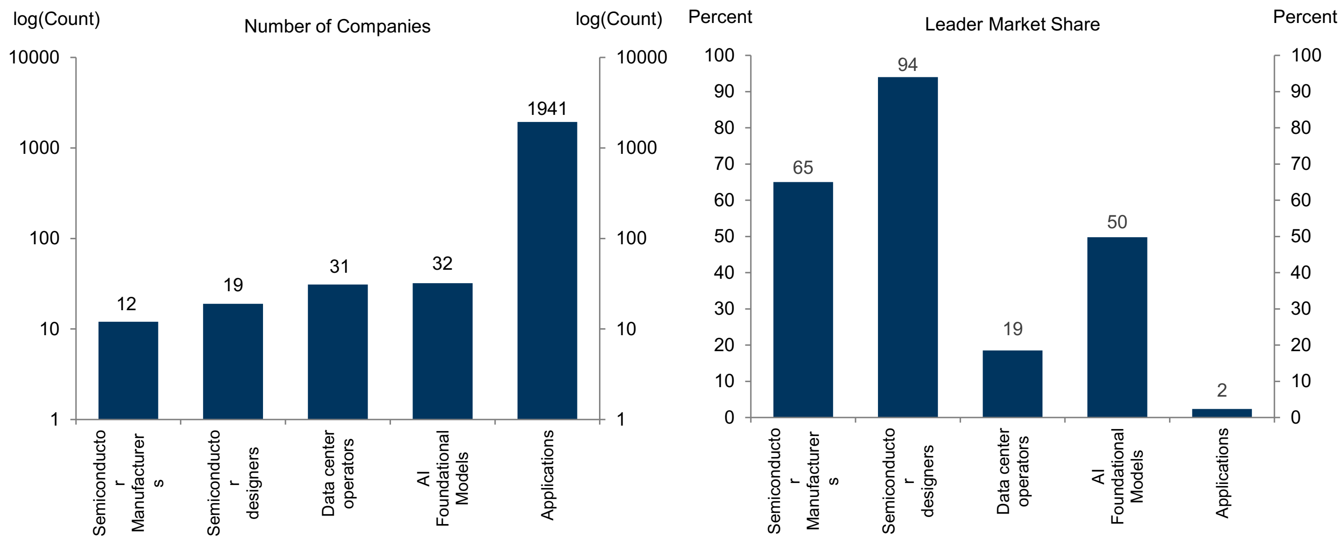
Note: Red shading indicates underperformance, green outperformance, yellow neutral performance.

Source: Goldman Sachs Global Investment Research

The market structure of the current AI stack provides limited clarity into whether the companies leading AI investments today will be long-run AI winners. Exhibit 11 summarizes the competitive landscape using data on new entrants and startups that have received funding (from CB Insights), which we augment with data from a variety of other sources (including Epoch AI, Anterio, Bloomberg, and public records). The left chart shows the number of companies (regardless of size) at each layer, while the right chart shows the market share of the leading firm.

The punchline from this exercise is that currently the AI stack appears very competitive at the application layer, reasonably so at the foundational model (despite OpenAI’s lead) and data center layers, and less competitive at the semiconductor layer (where Nvidia dominates semiconductor design, and TSMC dominates semiconductor production). The current market structure therefore suggests outsized returns for AI hardware providers, consistent with pricing of the AI trade so far.

Exhibit 11: Current Market Structure Looks Very Competitive at Application Layer, Less So for Semiconductors



Source: Goldman Sachs Global Investment Research, Epoch AI, CBI, Bloomberg, Anterio

The key question for investment sustainability, however, is whether incumbent advantages at the foundational model layer—i.e., the hyperscalers that account for the majority of AI capex today—will lead to outsized returns over the longer-run that justify continued investment. Academic studies of "first-mover" vs. "fast-follower" advantages (summarized in Exhibit 12) again provide mixed signals on the prospect for outsized market share and returns.

On one hand, academic studies suggest first movers can command outsized returns when high costs and limited access to key assets restrict competition or when vertical integration allows first movers to command control of the entire production stack. Along these lines, the high costs of AI investment, recent moves by OpenAI and other hyperscalers to lock up key computing resources, and increasing signs of vertical integration (primarily upstream; Exhibit 13) suggest that AI hyperscalers may be successful in maintaining their first-mover advantage.

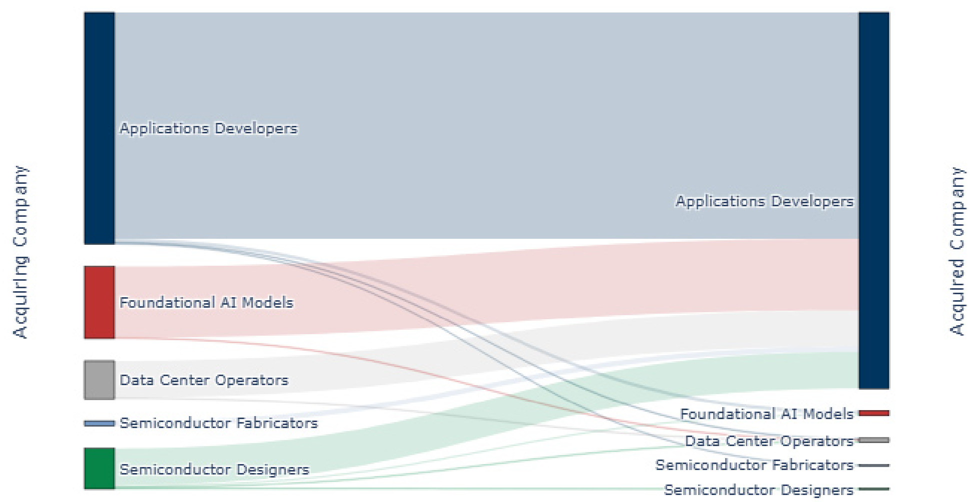
Exhibit 12: Academic Studies Suggest First Mover Advantages are Largest When Scarce Assets are Necessary for Product Development and Are Vertically Integrated; Smaller When Technological Change Is Occurring Quickly

First Mover Dominant	Fast Follower Dominant	Implications For AI Leaders Today
High switching costs	Low switching costs	Uncertain
Network effects established by first-mover product determine standards	Product market standards undetermined	
Network effects improve product quality	Product quality determined independently of network effects	
Scarce assets necessary for product development	Complementary assets abundant	AI Leaders Outperform
The technology stack is vertically integrated	The technological stack is separately owned and easily redeployed	
High cost of imitation	Low cost of imitation	
Slow technological change	Fast technological change	AI Leaders Underperform
Slow market growth	Fast market growth	
Patent/IP protections strong	Patent/IP protections weak	
Customer uncertainty on use low	Customer uncertainty on use high	

Note: Red shading indicates reason for potential underperformance, green outperformance, yellow neutral performance.

Source: UN COMTRADE, Goldman Sachs Global Investment Research

Exhibit 13: Acquisitions Have Mostly Been Concentrated Upstream in the Application Layer

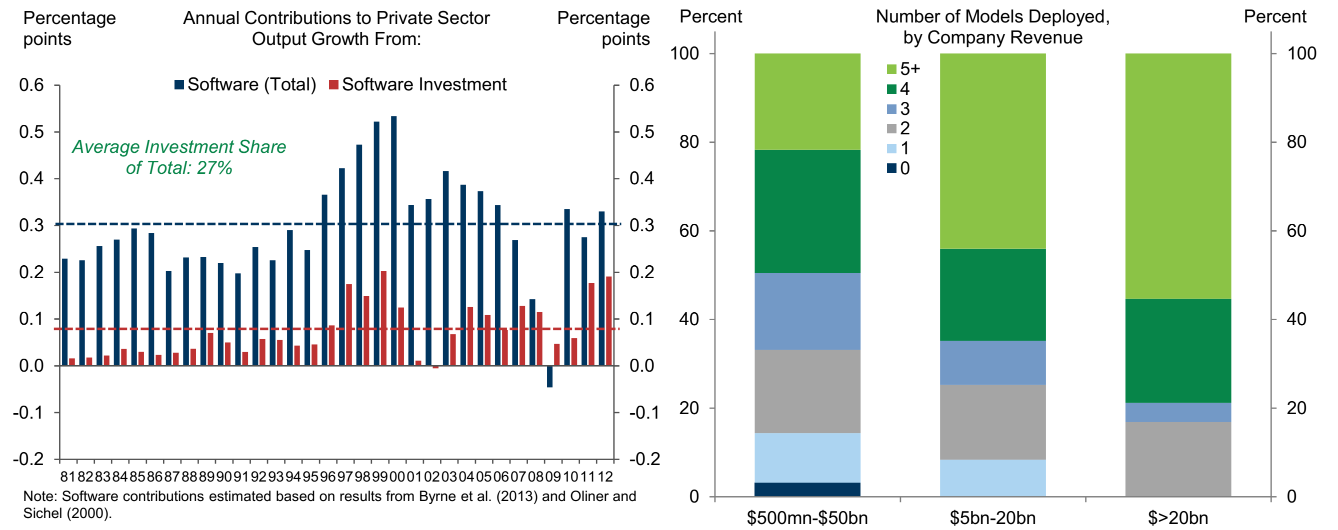


Source: Goldman Sachs Global Investment Research, CBI

On the other hand, first-mover advantages have historically proven smaller when technology and market growth are happening at a rapid pace, IP protections are limited, or when significant uncertainty around end-user applications exists. These patterns argue against advantages for AI hyperscalers that would justify sustained capex.

Other key determinants of first-mover advantages remain uncertain. IT platforms (e.g., Microsoft and other software providers) were able to tightly integrate into business processes during the 1980s, 1990s and 2000s, with high switching costs enabling them to capture an estimated 27% of the productivity benefits delivered by software over this period (left chart, Exhibit 14). In contrast, most companies today are diversifying across foundational models (right chart, Exhibit 14), which could limit switching costs going forward. Similarly, it is unclear whether first movers will benefit from network effects that help determine standards and quality.

Exhibit 14: Software Providers Were Able to Leverage High Switching Costs and Strong Network Effects to Capture Outsized Rents from IT Productivity Boosts, but Diversification Across Models May Lower Platform Switching Costs



Source: Goldman Sachs Global Investment Research, Andreessen Horowitz

The Case for Continued Spending

The key takeaway from our analysis is that the enormous economic value promised by generative AI justifies the current investment in AI infrastructure and that overall levels of AI investment appear sustainable as long as companies expect that investment today will generate outsized returns over the long run. This conclusion aligns with recent work from our portfolio strategy team that concludes we are not in a bubble.

We therefore expect that the solid macro backdrop will support capex for as long as companies believe that 1) a first-mover advantage will allow them to capture an outsized share of AI productivity-related revenues or 2) continued investment in compute capacity will drive improvement in model performance and potential development of AGI, an occurrence that could drive very outsized profits. AI investment may remain sensitive to news on either of these dimensions.

Joseph Briggs

Disclosure Appendix

Reg AC

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