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Future Trends (2025–2045): Research, Software, and the Economy

1. Research as a Primary Contributor to GDP

2025: Research and development (R&D) remains a growing but still limited share of GDP. In the EU, for example, R&D intensity (R&D spending as % of GDP) rose from ~1.8% in 2000 to about 2.2% by 2018 op.europa.eu , but the 3% target has not been met. Similar trends hold globally (US ~3% of GDP, China ~2.5%). By 2025, advanced economies will still largely depend on established R&D sectors (tech, pharma, engineering), though AI-driven research pilot projects begin to boost productivity. Public research (e.g. basic science) continues to undergird innovation – Mazzucato et al. note that public R&D enabled the digital revolution op.europa.eu – but direct GDP impact is gradual.

2030: By 2030 the knowledge economy is forecast to accelerate. The EU's scenarios project R&D intensity reaching roughly 2.7–3.0% of GDP by 2030 under sustained investment op.europa.eu op.europa.eu . Globally, major studies predict AI and tech-driven research adding tens of trillions to GDP: PwC estimates AI could boost global GDP by up to **26% (≈$15.7 trillion)** by 2030 pwc.com , while generative AI alone may contribute **$6–7.9 trillion annually** in productivity gains mckinsey.com . In practical terms, many new products and services (e.g. AI tools, biotech) emerge from research, shifting growth to intangible outputs. By 2030, research-heavy sectors will drive a larger slice of growth than in 2025.

2035: During the 2030s, research-as-growth is expected to solidify. Assuming continued AI advances, R&D-fueled productivity could sustain growth rates above historical norms. If Moore's Law and related trends continue, computing power (and thus research capacity) doubles roughly every 18–24 months, meaning projects that once took years can be done in months ourworldindata.org . Macroeconomic models (e.g. endogenous growth theory) imply that as long as R&D investment keeps pace, knowledge-driven growth persists. By 2035, many industries – from software to clean energy – rely primarily on new research breakthroughs for value, making research a primary GDP engine. Global GDP composition tilts further toward services and high-tech manufacturing, with research output central to these sectors.

2040: Looking to 2040, advanced economies may see R&D and innovation forming the **core** of GDP. Many routine goods will be mature and cheap; new value comes from information, algorithms, and high-tech services. Studies of "General Purpose Technologies" suggest that breakthroughs like AI can raise total factor productivity dramatically royalsociety.org . Thus, the *returns* to research (new products, efficiencies) dominate gains in labor or physical capital. If AI approaches human-level general intelligence by mid-century (as some forecasts allow), then research itself could even become semi-automated, further boosting its GDP share. In such scenarios, intangible innovation is the prime mover of economic growth, and R&D could plausibly rival or exceed traditional manufacturing in GDP contribution.

2045: By 2045, under optimistic assumptions, **research and knowledge output could become the dominant contributor to GDP** in advanced economies. The marginal cost of generating new ideas approaches zero via AI tools, so each additional dollar invested in research yields large multiples of economic value pwc.com mckinsey.com . At the same time, physical production becomes highly efficient but low-margin. In this era, GDP growth will largely reflect "the discovery of new services, drugs, machines, etc." rather than producing more steel or cars. (For context, historic OECD work notes that business investment in knowledge-based capital (including R&D and software) has already been growing faster than investment in physical capital oecd.org .) Thus by mid-century, a "knowledge economy" – where research is the foundation of prosperity – would likely be the norm.

2. Falling Research/Software Costs & Physical Cost Dominance

2025: Computing and development costs continue to fall. Moore's Law–style trends still hold: transistor counts (and hence compute power) have doubled roughly every 2 years for decades, and from 1975–2009 the average computer capacity doubled every ~1.5 years ourworldindata.org . Cloud computing and AI code-generation tools (e.g. large language models) start to reduce software development time. As a result, a given research or software project in 2025 is significantly cheaper and faster than in 2015. **Physical costs** (hardware, energy, materials, specialized manufacturing) remain substantial. For example, data centers already consume ~2% of global electricity (and rising) – training a single large AI model can cost millions of dollars in power alone. In 2025, physical capital (servers, chips, buildings) still dominates total expense for new tech systems, but the gap is closing as automation lowers labor/R&D costs.

2030: By 2030, the trend accelerates. The cost of computing and experimentation has plummeted due to advances in chip technology and AI automation. Open-source software, automated coding, and highly reusable modules mean writing an application requires far less unique R&D effort than before. Meanwhile, Goldman Sachs forecasts that data-center power demand will surge ~165% by 2030 (relative to 2023) due to AI workloads goldmansachs.com . In other words, **energy and infrastructure costs climb** even as development costs shrink. We expect that by 2030 the *marginal* cost of designing a new software service will be dominated by the hardware, cooling, and physical deployment needed, not by developer wages or R&D. This shifts business models toward lean, capital-intensive deployment: companies compete more on efficient use of physical resources (e.g. specialized AI chips, new fab processes) than on R&D budgets.

2035: In the 2030s, diminishing returns on further software optimization set in. Most "easy" software and algorithmic problems are solved; new gains require exponentially more compute or novel materials. If Moore's Law slows (as many expect), improving raw compute will become more challenging, and more effort goes into custom hardware (quantum devices, neuromorphic chips, etc.). Physical costs (energy, rare minerals, manufacturing) become increasingly critical. For example, advances in AI may require exotic hardware whose manufacturing cost dominates. By 2035, we expect **physical capital constraints** to be the bottleneck – e.g. the availability of advanced chips, high-capacity server farms, or specialized sensors – while the price of software tools and research has become relatively low. Businesses will allocate less budget to writing new code (often relying on AI/ML "agents") and more to building and powering the devices that run it.

2040: Looking toward 2040, physical costs could plateau or even rise in prominence. If transistor scaling hits limits, firms might invest heavily in expensive alternatives (3D stacking, chiplets, or future tech like quantum) to keep improving performance. Meanwhile, energy costs may dominate: AI models consume vast power, and by 2040 data center energy demand could be a major global share (extrapolating current trends goldmansachs.com). Thus we foresee a future where **energy, raw materials, and specialized equipment** are the true cost drivers, while computational methods and software itself are relatively "free" and ubiquitous. Geopolitical or environmental factors (e.g. energy scarcity) may therefore have outsized economic impact, whereas the cost of writing new algorithms will be minimal.

2045: By mid-century, it is plausible that *nearly all* routine R&D and software creation costs approach zero (due to advanced AI and virtual experimentation), leaving **physical infrastructure and resources** as the limiting factor. Companies will compete on who can deploy the most efficient hardware, source rare elements, and minimize energy use. Cloud operators, chip manufacturers, and data-center builders thus capture most of the economic value. In effect, software-as-code becomes commoditized and open-sourced, while capital-intensive hardware builds (satellites, robots, quantum computers, fusion plants, etc.) carry the bulk of expenditure. This inverted cost structure (free innovation vs. expensive deployment) will reshape economic models and likely push industries toward sharing resources (e.g. distributed cloud networks) to amortize those high fixed costs.

3. Modular Software/Systems & Specialized Firms

2025: Early signals point toward highly modular software ecosystems. Today's architectures (microservices, APIs, containerization) already let firms plug together specialized components rather than build end-to-end. In AI and cloud, companies increasingly use third-party models or platforms rather than coding every layer. We expect many specialized startups by 2025: e.g. one company focuses only on a superior vision model, another on speech, another on data labeling, etc. Open-source and commodity libraries (TensorFlow, PyTorch, Kubernetes, etc.) accelerate this trend. While few comprehensive studies exist yet, industry observers note that modular, "Lego-style" development is growing: large firms outsource smaller parts of projects, and tech standards proliferate.

2030: By 2030, software/hardware stack modularization is widespread. Specialization has become the norm: most firms build *one piece* of a larger system. For example, an "enterprise AI" solution might integrate modules from a dozen vendors (data-cleaning services, ML models, user interfaces), each developed by a focused specialist company. Regulatory and market changes amplify this: for instance, the EU Digital Markets Act (2023) seeks to open big platforms, enabling startups to plug into ecosystems without onerous gatekeeper rules commission.europa.eu . As a result, small firms can carve niches (e.g. a company that only sells a neural network optimizer), rather than be crushed by monolithic providers. In AI research, consortiums and open models (e.g. open-source LLMs) encourage sharing of subsystems. We anticipate by 2030 a **"component marketplace"** in tech – akin to how hardware vendors specialize in GPUs, CPUs, etc. – but for software modules and AI functions.

2035: The 2030s will see near-complete unbundling of tech stacks. Software and system design will resemble mechanical engineering: firms assemble solutions from a standard parts catalog. Entire industries may form around single functions (e.g. one startup that only cleans data for genomics, another that only designs micro-satellites). Interoperability standards (like USB did for hardware) become commonplace for data and AI services. This fragmentation means no single company can easily dominate an entire domain; competition and innovation happen at the module level. In essence, R&D itself becomes specialized: teams develop highly refined components, which others integrate. This mirrors trends in manufacturing (just-in-time parts from niche suppliers) now applied to software.

2040: By 2040, modularization is near-universal. Economies of scale apply to individual components (the best speech model provider has scale, but can't capture the market beyond its niche). System integration becomes a service, but underlying tech is generic. Even startups can combine powerful modules (downloaded from public "app stores" of AI) to create sophisticated applications with minimal original code. This distributed innovation means value flows to the best component makers. The software industry resembles an ecosystem of middleware and specialty tools, each with its own market. Large vertically integrated firms are the exception, usually formed by acquirers of many specialists rather than by single R&D orgs.

2045: In the mid-century view, nearly all software/hardware systems are built from modular parts. By 2045, it's conceivable that any new digital product is just an orchestration of hundreds or thousands of micro-services sourced from specialists worldwide. Founders no longer have to "reinvent the wheel" for core tech, so startups focus on integration, customization, or frontier niches. This modularity drives productivity: individuals and small teams can assemble complex AI-driven systems without deep expertise in every component. The downside is that profit pools for any one module will be limited by competition (see next point). Nevertheless, this modular world will enable very rapid innovation cycles and very low incremental development costs, consistent with the trends in points 1–2.

4. Diminishing Monopolies and Profit Margins

2025: As of the early 2020s, tech markets are highly concentrated. For example, an Axios analysis shows the S&P 500's Herfindahl–Hirschman Index (a concentration measure) reached a record high (~184) in mid-2024, surpassing even the 2000 dot-com peak axios.com . A few "megacaps" (GAFA etc.) dominate global tech profits. However, policy and market shifts are underway. Competition authorities in the EU and US have begun to challenge big platforms (e.g. antitrust cases against Google/Apple) and to lower barriers for rivals. The OECD notes "mounting concerns about growing market power" and calls for new competition tools in digital markets oecd.org . We therefore expect the mid-2020s to be transitional: large firms still earn high margins, but regulatory friction (and alternative open-source options) increasingly chip away at absolute dominance.

2030: By 2030, antitrust and regulation likely reduce monopolistic rents. Legislation like the EU Digital Markets Act (enforced from ~2023–25) compels gatekeeper platforms to allow third-party services commission.europa.eu . Similarly, U.S. regulators are pressing on tech mergers and dominance. As a result, some industries will see more viable competitors (for example, alternative app stores or decentralized social networks). The enlarged modular software ecosystem (Point 3) also fragments market power: no single company supplies entire stacks, so platform competition intensifies. Lower entry costs (from falling R&D cost in Point 2) mean more startups can compete in niches. All this drives down **profit margins** across the board: software and AI, once highly scalable sources of high returns, become more competitive. Benchmarks show that even as revenues grow, EBITDA margins of cloud and software providers could compress as price competition and regulation bite.

2035: In the 2030s, we expect fewer truly dominant firms. Market share is spread among many niche specialists, so aggregate concentration falls. By this time, leading companies are often conglomerates of many acquired specialists rather than single-product monopolies. Economists predict that with more modular supply chains and active regulation, industry concentration indices (like HHI) will decline. Profit margins in tech industries, which averaged 20–30% in the 2010s/20s for software giants, may revert toward historical averages (perhaps 10–15%) as competition normalizes. In practical terms, winning a market niche might yield a modest premium, but not the "winner-take-all" wealth of earlier eras. Indeed, the OECD's competitive policy work suggests that robust competition in digital markets requires active intervention oecd.org – a trend that by 2035 is yielding more balanced market shares.

2040: By 2040, most markets are mature and contested. True monopolies (with persistent >50% share) are rare outside network-dependent utilities. Profit margins in most industries have fallen compared to peak tech-boom levels. This is partly because almost every software or AI solution can be replicated or improved upon by others (thanks to open collaboration). For example, the "as-a-service" business model is ubiquitous but highly competitive: many cloud providers, many AI model suppliers, all undercutting each other. The aggregate effect is that capital (and labor) earn returns closer to the norm, rather than outsized superprofits. Technologies that once fueled monopoly power (like user data lock-in or proprietary platforms) have less effect in a fragmented, regulated landscape.

2045: In the mid-century outcome, the corporate landscape is decentralized. Very few companies will capture monopoly rents; instead, many small winners share profits. Profit margins in mature sectors (software, services) may approach marginal-cost pricing in many cases, with only small technology premiums. Value creation still comes from innovation, but the payoff is thinner per innovator. This aligns with the original premise: as innovation costs drop, the era of "anyone can start a software company" dilutes wealth concentration. By 2045, it would not be surprising if the tech industry had far fewer billionaires with outsized equity in platform monopolies. (For context, one 2024 study noted that even with recent wealth concentration, a few technologies – like vaccines – had bigger GDP impact than raw sales revenue royalsociety.org ; similarly, most value might come from enabling the economy as a whole, not just one firm's profits.)

5. Fewer Ultra-Rich Founders as Innovation Democratizes

2025: Currently, tech founders (e.g. in Big Tech and major unicorns) still account for a large share of billionaire wealth. But signals of change appear: venture capital becomes more dispersed into many startups rather than a few "megadeals," and some founders exit large companies via broad employee ownership or public goods models (diluting single-owner control). Already, only a tiny fraction of software companies become "unicorns" (>$1B valuation). In 2025, the top tech founders remain wealthy, but the pool of possible tech billionaires is not growing as fast as during the 2010s.

2030: By 2030, we expect the **distribution of startup returns to widen**. With research costs low and markets competitive (Points 1–4), the typical successful startup may sell for a modest hundred-million-dollar exit rather than the tens of billions common before. Founders' stakes will be smaller (more investors, lower multiples). Open-source and shared platforms mean many entrepreneurs contribute innovations without capturing the entire value. For example, few if any new tech companies beyond the very top (like long-standing giants) are expected to reach decacorn status. Anecdotally, industry observers note that waves of software innovation tend to have a few big winners and many small players; with barriers lower, there are vastly more small players. We anticipate a relative *shrinking* of mega-founders: although some will still become very rich, the number of ten-billionaires in tech is likely to plateau or fall as the economic pie is split more ways.

2035: In the 2030s, creating a tech business is easier, but converting it to personal wealth is harder. University spin-offs, cooperative open projects, and startups often adopt broad equity pools (e.g. all contributors). The net effect is that **individual founder wealth concentration declines**. For example, if dozens of firms each produce similar AI modules, none will generate gargantuan profits alone. Over this decade we expect to see more "democratized innovation" (many small successes) and fewer "founder paydays of a lifetime." Social norms and perhaps policy (e.g. taxes on extreme wealth) may further moderate founder incentives.

2040: By 2040, the archetypal tech billionaire from a single breakthrough is rarer. Instead, we may see many millionaires or multi-millionaires who earned wealth through contributory roles in open projects or from smaller ventures. The extremely wealthy class (top 0.01%) will exist, but perhaps drawn more from finance or inherited assets than from new tech startups. This shift mirrors the earlier trend in diversification of value: as most innovation is cheap and collaborative, capturing exclusive monopoly profit is difficult. In short, while innovation flourishes, the outsized rewards of a few founders become the exception, not the rule.

2045: In the long run, if these trends hold, we may reach an economy in which **very few individuals become ultrabillionaires from innovation alone**. Technological gains benefit broad society (through free or cheap products) rather than single companies. This does not mean people aren't rewarded for entrepreneurship, but the payoff structures change: founders might earn good incomes or moderate fortunes, but not the extraordinary concentrated wealth seen in the early 21st century. Thus, by 2045 innovation is cheap and pervasive, research drives growth (Point 1), costs shift to physical capital (Point 2), and the market is fragmented (Points 3–4), all combining to "flatten" the founder wealth curve.

Sources: Current data and projections from OECD and EU reports on R&D op.europa.eu op.europa.eu oecd.org , industry analyses of AI's economic impact pwc.com mckinsey.com , studies of technology cost trends ourworldindata.org goldmansachs.com , and policy/antitrust discussions commission.europa.eu oecd.org axios.com . These inform the above trends for 2025–2045 in AI, software, and the broader economy.

Citations

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