Want Us Semiconductor Leadership? Fix The Tax Code

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Image credit: Alex Taliesen

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Introduction

Recent events starkly highlighted the importance of semiconductors to the US economy and the fragility of the US semiconductor supply chain. These shortages were estimated to have cost over a full percentage point of 2021 US GDP,[1] prompting Congress to pass the 2022 CHIPS and Science Act to level the playing field for onshore semiconductor manufacturing after decades of decline.

However, unrelated tax code changes are threatening to unravel any benefit from the CHIPS Act. New 2022 regulations that disallow the same-year expensing of investments in research and development (R&D) have perversely made the already-uncompetitive US tax code even more punitive to innovation. These disincentives to R&D risk harming US competitiveness across all high-tech fields, including those sectors where the US currently leads.

The impact is especially great to the semiconductor industry. In every corner of the semiconductor ecosystem, R&D costs are rising dramatically due to the challenges of the slowing of Moore's Law and increasing international competition, forcing all companies to run even faster on existing product roadmaps, while simultaneously investing in higher-risk technology. The semiconductor industry has always depended on large R&D expenditures, but today the pressures are even greater due to the exploding complexity of technology.

Such pressures have already driven many companies to focus on existing "cash-cow" product lines rather than investing in the requisite R&D to stay current. By slashing R&D funding and giving up on maintaining the cutting edge, companies can increase near-term profitability and return cash to shareholders. These companies run the risk, however, of obsolescence and demise within a few years.

For companies in other sectors where large R&D spending is mandatory, the risk of underinvestment in R&D is larger today than ever, especially with the headwinds of a potential economic downturn. Declining revenues usually mean that cuts must be made, and R&D investment in future products is often the only available lever. However, long development pipelines mean the gaps will not be obvious for years, at which point they will be too large to remedy.

In this environment, the 2022 tax code changes are uniquely damaging. While meant to help pay for lower overall corporate tax rates, the changes punish the nation's high-tech industries by penalizing the very innovation that drives progress and growth. Research-intensive industries are paying for lower tax rates for larger but less R&D-dependent industries. The beneficiaries are industries such as financial, service, and retail. The result will be perverse harm to the high technology industries of the US.

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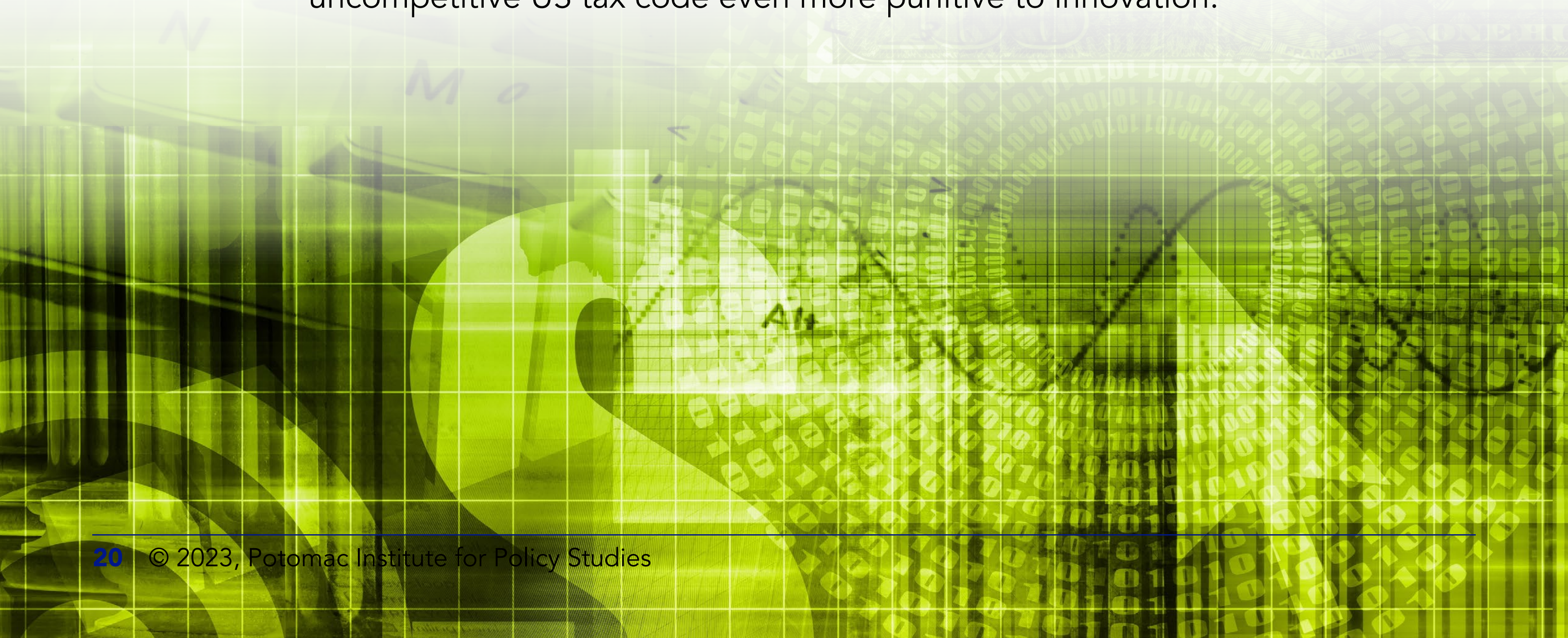


Such policies stand in stark contrast to those of Asian countries (including China)—all of whom have realized the importance of innovation, erecting favorable R&D tax policies to promote technology development. The US is risking national security due to an anticompetitive tax code that penalizes innovation.

Semiconductor R&D

Modern semiconductor devices are appropriately recognized as the most complex mass-produced products in history, as documented by Chris Miller's 2022 book *Chip War*.[2] A vast ecosystem of specialized engineering domains erected over decades feeds a progression of ever-more-complex new chips, governed by the drumbeat of Moore's Law. Devices such as processors, memory devices, sensors, and communication chips help make usable information out of the mountains of raw data that inundate us daily. Novel architectures enable new applications such as artificial intelligence (AI). Moreover, as recent military news makes clear, our critical defense systems are also critically dependent on secure access to semiconductors.[3]

The costs to fuel these innovations have skyrocketed. Costs are driven in tandem by manufacturing and design complexity. While Moore's Law has delivered the capability to form trillions of shapes no larger than the width of a small molecule, future advancements require new techniques using the most precise manufacturing gear ever created (and thus the most expensive). Specialized multi-billion-dollar development fabrication facilities (fabs) are staffed with large teams of R&D engineers working on a pipeline of next-generation processes.

This R&D may start up to a decade before transfer to manufacturing. Investigations begin with basic research of new materials, then move to applied research to prove basic production capability, and finally on to development of prototypes to ensure high-volume repeatability. This progression is necessary to establish readiness for the high stakes of prime-time manufacturing, with costs and urgency rising with each step. The results of every project must be evaluated carefully to justify further investment, with only the most promising approaches allowed to continue. A company that stumbles will require even greater investments in R&D to attempt to catch up. Intel's recent delays introducing 10nm and 7nm manufacturing nodes highlight the inherent risks in the development and deployment of cutting-edge manufacturing processes.[4]

Design teams face similar challenges, often mobilizing 1000+ member teams to craft complex chips. Modern "System-on-Chip" (SoC) designs are filled with thousands of synchronized sub-systems, including hundreds of processors, memory blocks, and interface circuits—all on one chip. Ensuring these pieces work together flawlessly requires hundreds of thousands of simulations using the latest electronic data automation (EDA) tools, resulting in multi-year design efforts that can cost well over $500 million in non-recurring engineering (NRE) charges. Once the design is complete, initial manufacturing runs may take the better part of a year, making "first-time-correct" methodology a must. Finding a design problem in silicon can add catastrophic delays, risking a missed market window and a significant reduction in the ability of the project to pay back its development costs.[5]

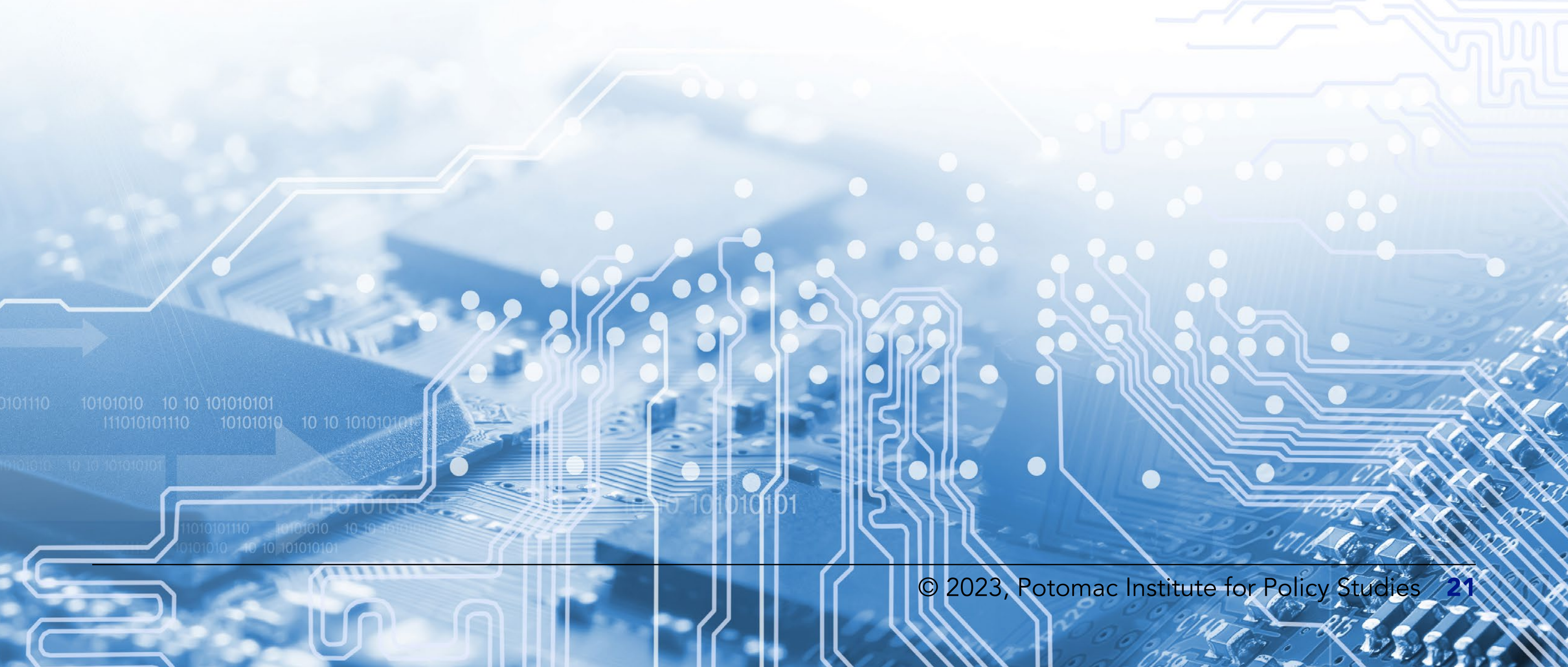
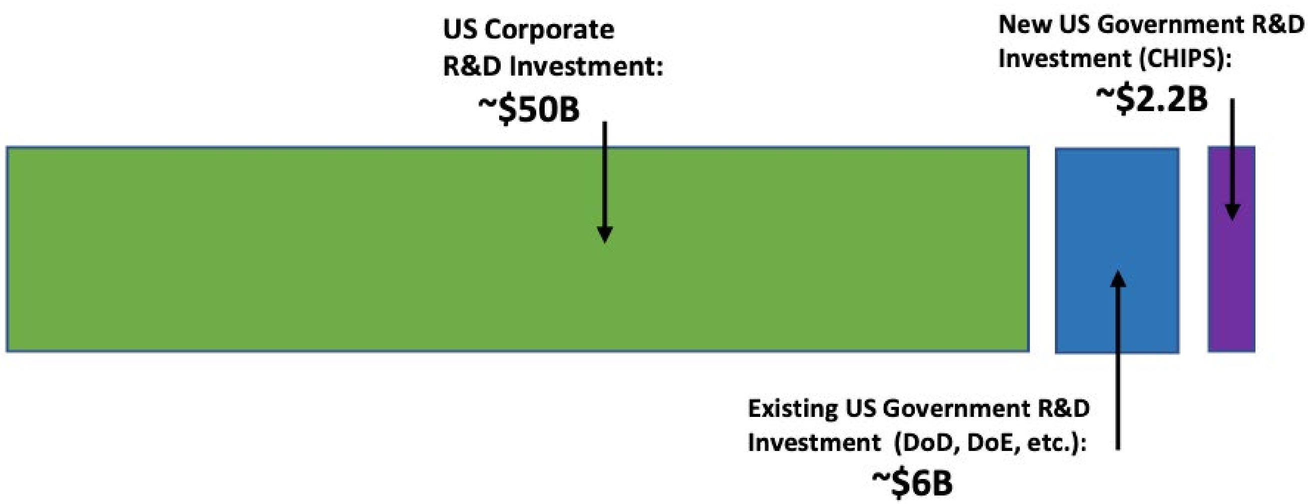


Figure 1. Annual US Semiconductor R&D Investment Sources



Notes: Figures represent estimates for FY2023. CHIPS R&D Investment of $11B total over the five years of FY2023-27, annualized as $2.2 billion per year. Sources: "American Semiconductor Research: Leadership Through Innovation," Semiconductor Industry Association (SIA); John VerWey, "Betting the House: Leveraging the CHIPS and Science Act to Increase US Microelectronic Supply Chain Resilience," CSET, January 2023.

This work transpires before a single chip is sold and amounts to a crushing R&D burden. But now a larger specter has emerged: Moore's Law is bumping up against the fundamental laws of physics. More than five decades of exponential physical scaling progress are at risk of ending, forcing a competition to discover new avenues for progress. For companies to expect to remain competitive, they must now pursue completely new disruptive innovations, known as "post-Moore" technologies. Such approaches include pushing structures into three dimensions, employing new elements, and finding new approaches to package multiple chips together.

These challenges require semiconductor manufacturers to invest a larger percentage of R&D into basic research, further straining budgets oversubscribed with nearer-term projects in more traditional corporate areas of applied R&D.

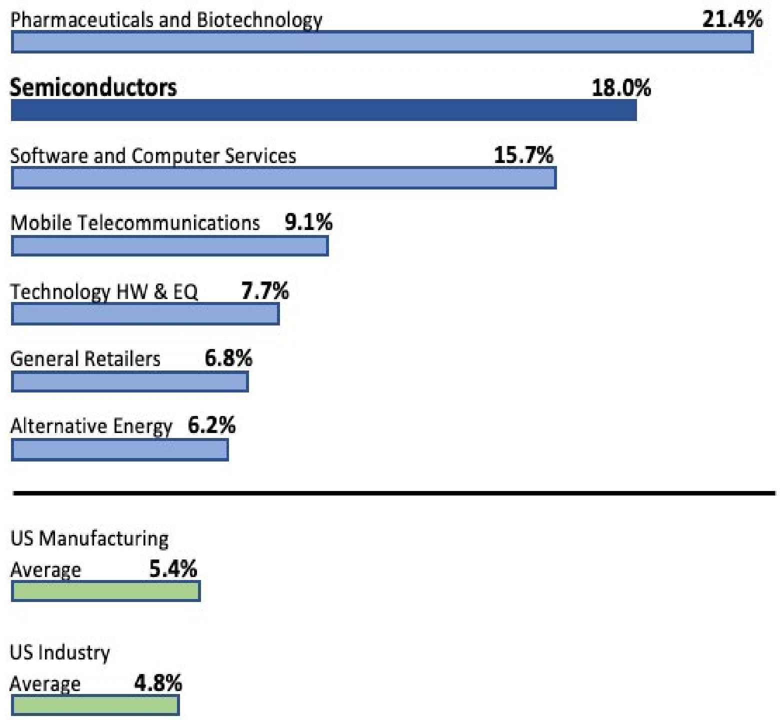
These same "post-Moore" challenges are driving design teams to employ new architectures, custom-built for the application, reminiscent of the "application-specific-integrated-circuits" (ASICs) products of the past. While offering significant performance gains, this in turn drives the need for more designs while incurring large development costs that are amortized over significantly fewer units in future sales, further straining R&D budgets.

Basic research, while perhaps offering significant new opportunities, is even more fraught with long lead-time and risk, and thus historically has been the domain for government-sponsored investment. However, US government spending in semiconductor R&D has declined drastically since the 1960s, with recent estimates near $6 billion, compared to annual corporate investment of about $50 billion. This spending has also been disproportionately focused on specialized Department of Defense and Energy needs with less commercial industry relevance.[6]

The CHIPS and Science Act of 2022 attempts to reverse this decline, by investing $11 billion in government-funded semiconductor R&D to be spent over five years on commercially relevant technology areas.[7] While a welcome infusion, corporate-funding of R&D will still strongly dominate in the semiconductor field, as Figure 1 illustrates.

The cost of innovation has pushed average US semiconductor R&D intensity (R&D as a percentage of revenue) to 18% in 2021. Semiconductors, together with pharmaceuticals (with an average R&D intensity of 21%) and

Figure 2. R&D Expenditures as a Percentage of Sales, Select Industries



Sources: "2022 State of the US Semiconductor Industry," Semiconductor Industry Association (SIA); Raymond M Wolfe, "InfoBrief NSF 22-343," National Center for Science and Engineering Statistics, October 2022.

software (at 16%), are the only US industrial sectors with R&D intensity over 10%.[8] For these types of high-tech sectors, R&D is the lifeblood essential to maintaining a business—not a minor sideline expense for product improvement, as in many other industrial sectors.

Of note, US semiconductor R&D intensity is the highest in the world, effectively double that of China, Taiwan, Japan, or South Korea.[9] R&D intensities for several notable US sectors are shown graphically in Figure 2.

High R&D intensity is essential to the long-term competitiveness of semiconductor companies in every segment, including those in fabless design, equipment, and EDA software. For advanced semiconductor manufacturers, annual R&D investment must be paired with even larger annual capital expenditures (capex) in manufacturing capacity. This investment in production fabs and equipment is necessary to transform new technology into usable manufacturing capability. However the combined costs are staggering. For comparison, the top five largest US pharmaceutical companies invested 22% of revenue in the sum of R&D and capex in 2021 (18% and 4%, respectively); the comparable figure for the advanced semiconductor manufacturing industry is 50%, broken down as 14% R&D and 36% capex.[10] The crushing combination of annual investments required to stay competitive in advanced semiconductor manufacturing is not found in any other industry.

This cost burden has fueled the decision by most manufacturers to exit advanced semiconductor manufacturing, typified most recently by Global Foundries' announcement stopping all R&D and manufacturing investment in 7nm and smaller nodes.[11] The result is that in state-of-the-art logic and memory manufacturing, only a small handful of worldwide companies remain, down from dozens in each field three decades ago.

These costs have also fueled shareholder pressure to minimize R&D, given short-term concerns on expenses, risk, and payback time, pushing instead for either an acquisition strategy[12] or a return of cash to shareholders. Other companies in cyclical sectors have been forced to cut core R&D at the bottom of the cycle, as the only discretionary lever available for survival, incurring large risk of technology development gaps that will not be obvious for years.

The International Playing Field

Spurred by decades of globalization and an understanding of the importance of semiconductors, multiple Asian countries have sought and attained leadership positions in advanced semiconductor production. Companies in these countries have felt the same rising R&D cost pressure as semiconductor firms everywhere. The respective national governments have responded by offering significant R&D incentives, for example:

- South Korea, home to Samsung Electronics and SK Hynix (the semiconductor arms of two of the largest South Korean chaebol), passed a bill offering R&D tax credits for indigenous semiconductor firms of up to 50%, as part of the "K-Belt" initiative announced in 2019. This initiative proposed upwards of $150 billion in government aid to local producers for both manufacturing and R&D assistance.[13]

- Taiwan, home to Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Corporation (UMC), likewise approved a bill in November of 2022 instituting a full 25% R&D tax credit, of notable help to TSMC in particular, with annual R&D expenditures of $4 billion.[14]

- China's semiconductor efforts were highlighted most notably with 2014's "Made-In-China" initiative, featuring not only tax credits but also direct subsidization of R&D.[15] More recently, in December 2022, China approved additional subsidies worth $143 billion to the nation's semiconductor producers.[16] Extension of broad-based R&D "super-deductions" offer all Chinese high-tech industries the opportunity for effectively "free" R&D.[17,18] The unfortunate ease with which high-volume commercial semiconductors can be reverse-engineered and copied has further accelerated the development efforts of China's companies, as well as notable cases of outright intellectual property (IP) theft (most recently, for example, in the cases of ARM,[19] ASML,[20] and Micron).[21]

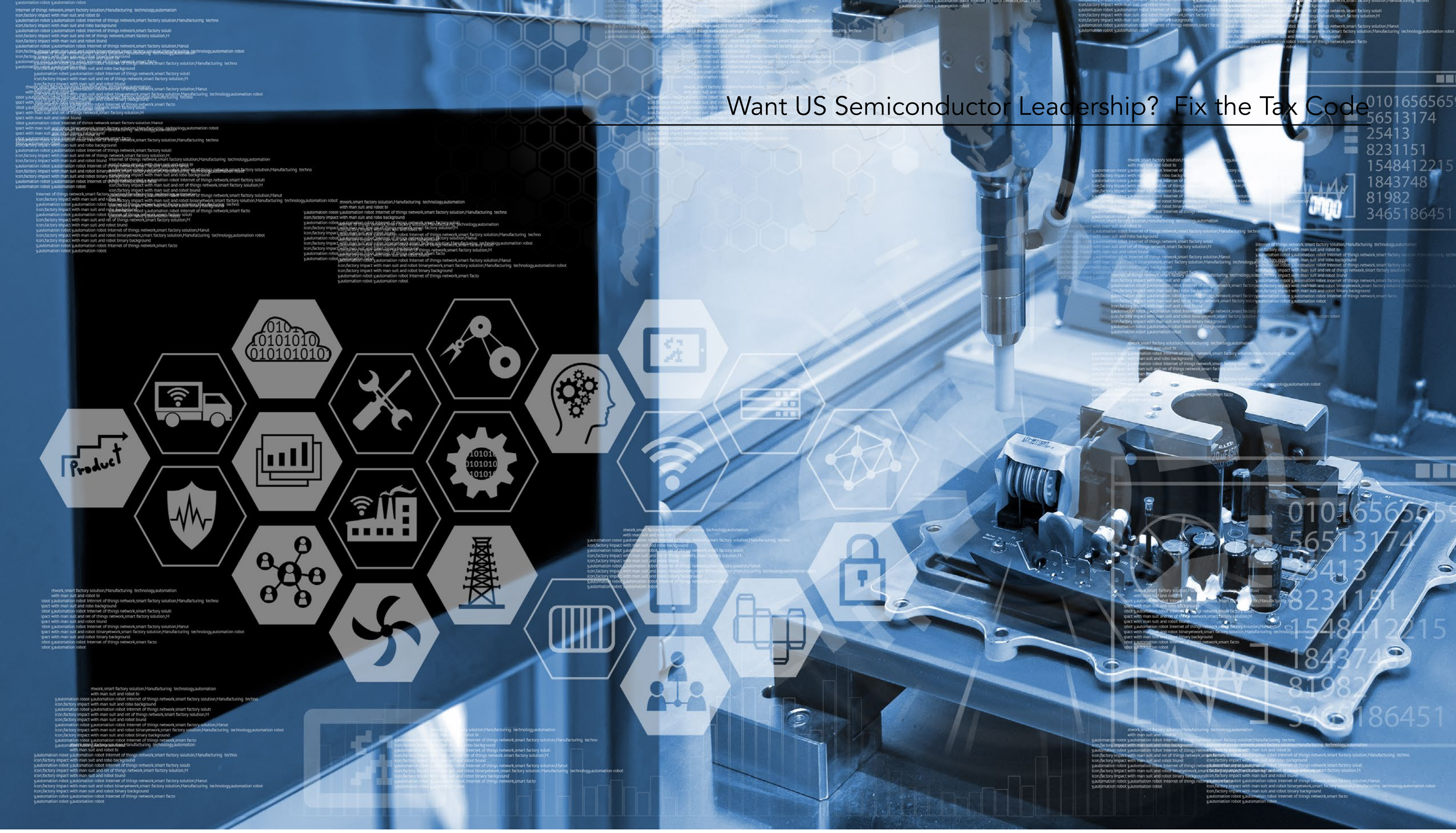
US Tax Policy

In the US, tax treatment of R&D has moved in the opposite direction. Changes to the tax code starting in 2022 require R&D to be amortized over a five-year period (fifteen years, if performed offshore) rather than deducted immediately (i.e., expensed). This modification to R&D tax treatment is part of the 2017 Tax Cuts and Job Act. The change was instituted putatively to help offset revenue loss from a reduction in US corporate top tax rates. The practical effect however was to punish R&D-intensive industries such as semiconductors, while benefitting industries with minimal R&D.

The transition from immediate deduction to a delayed depreciation schedule results in direct taxation of R&D. Companies moving to a five-year schedule will pay one-time federal and state taxes on the equivalent of 200% of their annual R&D expense (see box, below). This additional tax is of minimal concern for financial or retail companies, but a potentially multi-billion-dollar impact for R&D intensive companies. The financial hit is never recouped. Although accompanied by a reduced top federal corporate tax rate, the exposure of R&D spending to taxation—which is unique to the US among all OECD countries—is a powerful deterrent to R&D investment.

> Under steady-state R&D annual investment, the transition from immediate deduction to a five-year depreciation schedule implies additional tax basis in year 1 (2022) of 80% annual R&D, followed by 60% in year 2, 40% in year 3, and 20% in year 4, totaling to a one-time increase to the cumulative taxable base of 200% of annual R&D.

The transition of R&D to a depreciation schedule causes more than a one-time financial hit. Because today's R&D is not fully deductible until five years hence, inflation means that R&D investment will never be fully deducted due to the decline in time-value of money. Effectively, some percentage of R&D must be paid out of profit, which means that for tax purposes, R&D in the US is now treated worse than manufacturing expenses. (For manufacturers and retailers, non-capital costs, such as cost of goods sold, are deducted quickly in the quarter the product is sold).



The financial impact is not confined to the semiconductor industry. In October 2022, 178 CEOs across a broad base of R&D-intensive sectors signed a letter to Congress seeking repeal of the R&D deductibility change, with multiple firms reporting hits to 2022 profitability of greater than $100 million. Raytheon's CEO noted a 2022 impact of over $1.5 billion.[22] The effective penalization of R&D will hurt innovation in the US, causing more harm than simple economic losses.

The timing of the change could not be worse for the semiconductor industry, currently mired in a deep cyclical downturn (with multiple firms now reporting losses).[23] While any tax code change has winners and losers, selecting R&D-intensive industries to pay for an overall corporate tax reduction runs perversely counter to the stated US goals of increasing national R&D investment.

The US has featured a R&D tax credit since 1981; however, due to original design and subsequent revisions, it is quite limited in benefit to semiconductor companies. The credit only applies to 14% of the incremental increase in R&D spending over a rolling three-year average and is further limited to just R&D labor and supplies, specifically excluding all R&D capital.[24] Given long technology horizons and business cyclicality, the R&D budgets for most semiconductor companies, while massive, typically do not grow much year to year. R&D budgets for advanced semiconductor manufacturers are also very capital intensive, specifically for R&D fab shells and new, next-generation equipment. The value of the US tax credit is negligible to the semiconductor industry.

In contrast, the tax credits of South Korea, Taiwan, and China all apply to the entire R&D annual expense for semiconductor development (not just incremental increases), which provides in those countries significant ongoing subsidization of R&D investment.[25]

The CHIPS legislation of 2022 provided incentives for semiconductor manufacturing as well as funds for government-directed R&D. However, no incentives were provided for corporate R&D. The government-directed R&D funds, while welcome, pale in comparison to annual corporate R&D. Therefore, the government must leverage corporate R&D infrastructure (helping to avoid the cost and risk of a centralized national R&D fab such as Sematech but placing an even larger burden on healthy corporate R&D investment).

On a positive note, the CHIPS Act's manufacturing investment tax credits are already helping drive a resurgence in

US semiconductor fabs. Investment tax credits have the added feature of driving corporate "skin-in-the-game," as companies must invest their own capital first to receive a downstream proportional credit in return. Thus, companies affirm the viability of projects through their own financial commitments before receiving any taxpayer-funded benefit. However, the CHIPS Act investment tax credits are not applicable to R&D (nor capital purchases for R&D), thereby disparaging the value of R&D and undercutting the very intention of the CHIPS Act with respect to the semiconductor industry.

Prognosis

Surveying the semiconductor landscape, the US maintains the lead or is strongly competitive primarily in those segments with modest capital requirements, including EDA software, wafer equipment, and fabless design. In other critical areas however, such as semiconductor manufacturing, packaging, and compound semiconductors, the US has fallen behind. The US today is responsible for just 12% of global semiconductor manufacturing, falling from 37% in 1990 (and with the percentages for certain critical state-of-the-art technologies rounding to zero).[26,27]

Even in areas the US leads in today, the combination of skyrocketing semiconductor R&D cost, cyclical and systemic investment limitations, activist investor pressure, subsidized international competition, and state-sponsored IP theft are challenging US firms like no other time in history. On top of these already significant challenges, the US tax code's incentives for innovation have now moved from uncompetitive to anticompetitive. As many nations expand R&D tax credits and offer super-deductions, the US tax code's disallowing of immediate R&D deductions (therefore directly taxing R&D investment in the transition) poses a very real threat to US semiconductor companies' ability to afford adequate R&D to remain competitive.[28]

Proposals

The US depends on a sustainable and secure semiconductor industry, as acknowledged in the CHIPS and Science Act of 2022. The US Secretary of Commerce acknowledged in recent remarks that the "stakes couldn't be higher," and that "our success [with CHIPS] will be short-lived if we focus only on manufacturing."[29] Given the challenges that the industry now faces, we offer a set of proposals to help re-establish the US as a competitive home for semiconductor R&D:

1. **Immediately rescind (retroactively) the provision of the Tax Cut and Jobs Act of 2017 that forced qualified R&D to be depreciated over a minimum of five years.** This change has thrust the US into a unique level of punitive R&D tax treatment as the only nation disallowing immediate R&D expensing, just as the semiconductor industry is fighting through a downturn. Inflation makes delayed expensing even more painful. In 2022, both branches of Congress acknowledged significant bipartisan agreement on the damage resulting from this provision; however, resolution in the final Omnibus spending bill was forestalled.

2. **Expand CHIPS's Investment Tax Credits to be applicable to R&D capital expenses.** No other industry requires R&D capital at the scale and expense of semiconductor manufacturing, where development fabs must be built and equipped before R&D can start. A tilted R&D playing field means the newest tools are often shipping to Asian companies ahead of those in the US.[30] Expanding the investment tax credits to apply to R&D equipment would ensure that the latest cutting-edge equipment can be purchased competitively and timely by US producers. The cost of this extension would be a relatively minor increase of the CHIPS's tax credit costs, yet it would immediately improve the odds of CHIPS success by helping ensure the US is competitive in semiconductor manufacturing R&D.

3. **Update the R&D tax credit to be competitive with all other nations competing in semiconductors: A permanent, non-incremental, 25% tax credit applied to all qualified R&D performed in the US.** The US R&D tax credit has minimal value to US semiconductor manufacturers and other R&D-intensive sectors. Asian countries have used significantly larger R&D tax credits and subsidies to catch up to the US, often hiring students trained by leading US universities. To be competitive, the US needs to simplify, expand, and make permanent a US R&D tax credit, incentivizing US companies to continue investing their own skin-in-the-game in significant ongoing domestic R&D operations.

4. **Aggressively prosecute nation-sponsored IP theft.** While tax treatment of R&D is important, all will be for naught if large-scale nation-sponsored IP theft is allowed to continue. No company can rationalize R&D investment when the results are used to weaponize their competitors. Companies in the US invest over $500 billion in R&D, annually. Recent estimates place the annual theft of US IP by China at an identical $500 billion, illustrating the appalling scope of the issue, now acknowledged by both US political parties.[31] The solution will most assuredly rely on US government assistance, stronger coalitions of US allies, commitment to principles of IP protection, and aggressive and rapid prosecution of theft.

These actions would help the US recover as a thriving home to corporate R&D necessary for semiconductor leadership and would benefit other R&D-intensive fields critical to national security. The actions would provide incentives not only to large, established companies but also to startups pursuing disruptive blue-sky innovation. Current semiconductor challenges require massive and bold investments in innovative solutions and new technologies. The passage of CHIPS by the US acknowledges this need, however the success of CHIPS is predicated on a thriving corporate R&D ecosystem to deliver these solutions.

No tax policy discussion should ignore legitimate concerns of US deficits. We note, however, that R&D investment is universally acknowledged as one of the best levers to drive long-term growth in future tax-paying businesses and jobs. We also note that in recent years, corporate tax revenue in total has amounted to no more than 6% of all US annual tax receipts.[32] Quite simply, considerations around lost revenue from R&D tax treatment should be of vanishingly small priority relative to the larger concern of properly incentivizing the nation's technological competitiveness.

As Steve Jobs once noted, "Innovation distinguishes between a leader and a follower." The geopolitical competition in which the US finds itself will be won or lost based on the strength of our nation's technology base. Leadership in semiconductor design, fabrication technology, and next-generation technologies is a non-negotiable requirement for economic and national security. We cannot afford an anticompetitive R&D tax policy that acts to drive technology development offshore. Let's fix the US tax code to incentivize large, ongoing, onshore, corporate R&D investment to help ensure our future security.

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