

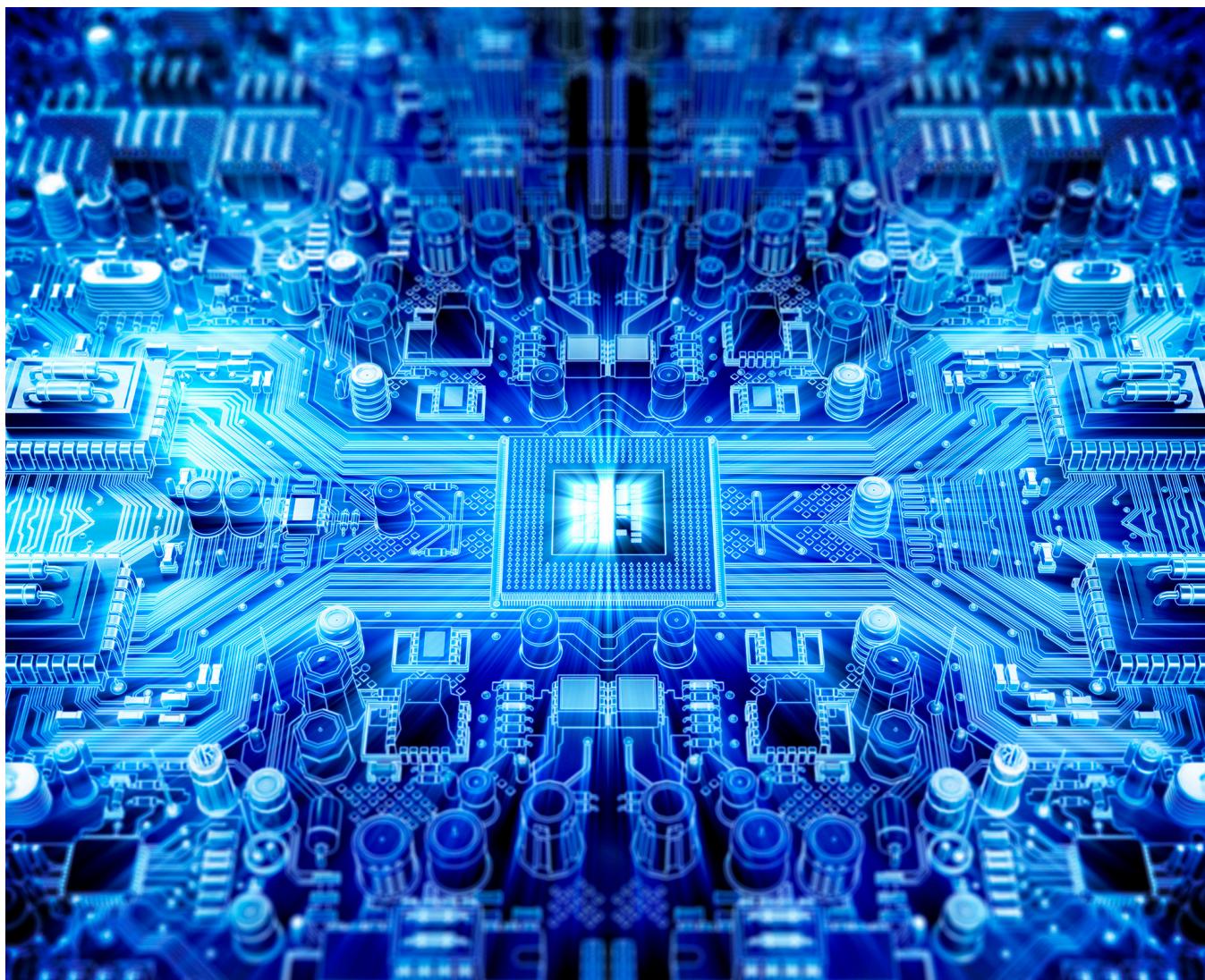
OUTLOOK

Semiconductors

AlixPartners
When it really matters.

Getting Moore out of Chips

Driving R&D efficiency after 50 years
of Moore's Law



Moore's law has ruled the semiconductor industry for 50 years. Of course Moore's law assumes it would make sense for transistor density to double every 18 to 24 months. In other words, it needs the market to justify the cost of staying on that trajectory. But that may no longer be true.

Although the industry could certainly use the computer power generated by leading-edge performance, the size of the market that needs leading-edge computer power is no longer able to support the research and development (R&D) required to deliver it. Even the explosive growth of smartphones using mobile systems on a chip (SoCs) that take advantage of leading-edge manufacturing has not enabled the industry to support the levels of R&D required to deliver transitions in main areas such as lithography and wafer size. That dynamic might bring about the end of Moore's law as we know it for the chip sector. But it doesn't mean companies can't continue to innovate—and to profit from their R&D investments.

Fewer winners with the scale to invest

The year 2014 saw strong, 8% growth in the semiconductor industry. Still, behind the numbers are disturbing trends. There was a large concentration of growth among a few players, and even then the growth was due mostly to a temporary increase in the average selling price of memory, which was caused by supply chain issues that created a shortage. Simply put, the industry is not growing nearly as fast as historical levels. As it surpasses \$300 billion in annual revenues, its growth has slowed because it takes massive product cycles to move the needle on a revenue base that large. Even revolutionary product categories such as smartphones and the Internet of Things will have a difficult time bringing revenue growth back to historical levels. Consolidation in the industry has created a concentration of revenue and earnings power at the top of the semiconductor industry: in 2014, the top 10% of companies in our survey of the top 72 publicly traded companies controlled more than 58% of the revenue and 70% of the operating profits in the sector (figure 1).

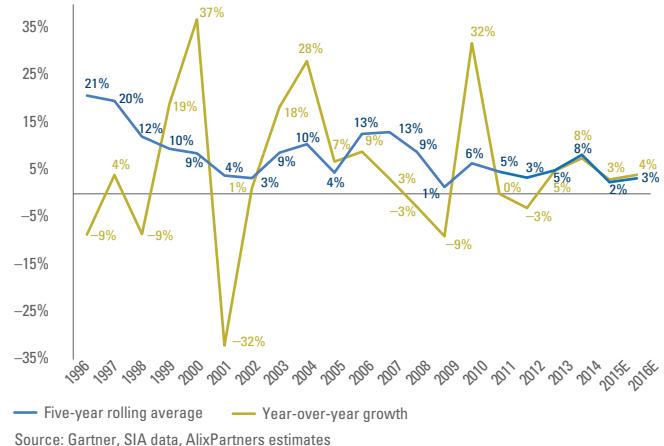
FIGURE 1: Revenue and operating profits in the semiconductor industry

	Revenue	Revenue (% of total)	Operating profit	Operating profit (% of total)	Operating margin
Top 10%	\$188B	58%	\$53B	71%	29%
Rest of semis	\$137B	42%	\$21B	29%	13%

Source: Capital IQ data and AlixPartners research

The past several weeks have seen a slew of downward revisions in forecasts for growth projections in 2015 from 7 to 8% year over year to low single digits, which is where we believe growth will end up for the year. Both Intel and Taiwan Semiconductor Manufacturing Company (TSMC) lowered their forecasts after missing first-quarter projections, and those lowered growth levels appear to be the rule more than the exception, as set forth in figure 1. Since the downturn in 2009 and sharp rebound in 2010, growth in the market has stabilized at a level that is approximately half of the long-term historical average (figure 2).

FIGURE 2: Semiconductor company revenue growth rate year-over-year and five-year rolling average

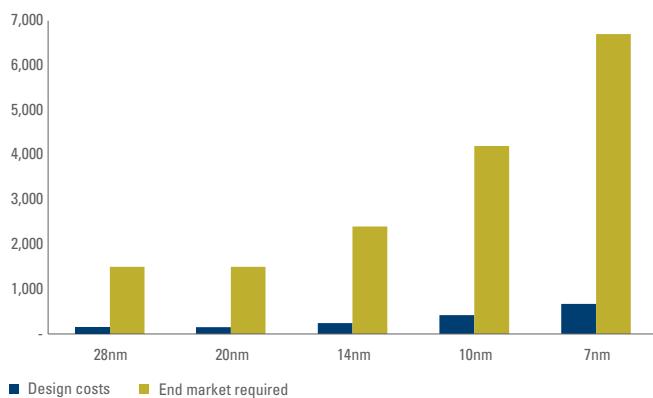


The high cost of Moore's law

Moore's law is alive and well within the walls of a select few semiconductor companies such as Intel, Samsung, TSMC, and chip designers such as Qualcomm and NVIDIA. The largest company in the world, Apple, is doing its part with its own leading-edge application-specific integrated-circuit (ASIC) design. But those companies have become the exceptions, not the rule. Most companies have changed their approach to Moore's law as they continue to introduce designs on newer process technologies. The rising costs of getting designs to market mean that fewer designs carry the burden of driving revenue growth, and bets on new products are getting bigger and bigger.

The increasing costs of R&D and new product introductions are leading the industry to a point where—because of the lack of end markets to support such a design—only a handful of new products can be developed on a new process technology within the critical ramp period. By 10 nanometers, a traditional SoC would need to capture a share upwards of 20% in a \$4-billion end market to break even based on a \$400-million estimated R&D budget (figure 3). That's a massive risk that only Apple, Qualcomm, and a few others can take.

FIGURE 3: End markets required to support design costs



Higher R&D costs mean fewer companies can continue to innovate, which leads to increased incentives to consolidate. And that's the driving force behind the mergers-and-acquisitions (M&A) deluge the industry has witnessed in the past several years. We can easily observe the large amount of M&A activity versus the small number of initial public offerings (IPOs) in the industry since the financial crisis (figure 4). On one hand, the paucity of IPOs shows that the market does not believe many of the smaller companies have the ability to capture necessary market share in profitable product segments in order to become sustainable entities on their own. On the other hand, companies seem very willing to buy up the smaller companies or pieces of other companies to integrate into their portfolios of offerings.

FIGURE 4: Number and value of industry transactions, 2009-2013

2009-13 industry totals	Transactions	Value
Mergers and acquisitions	1,092	\$110B
Initial public offerings	32	\$3.8B

Source: Factset

Consolidation isn't the only way companies are combating increasing R&D costs. Many companies are exploring new approaches such as 2.5-D and 3-D technologies. Others are looking at new applications on older technology nodes such as radio frequency or microelectro-mechanical systems (MEMS) on eight-inch wafers. Examples are Xilinx's use of 2.5-D interposers in the high-end field-programmable gate array market or Micron and Toshiba's use of 3-D applications for the memory market. Many other companies are exploring 3-D technologies as a hedge against the risk of traditional scaling by taking the traditional application of Moore's law out of the critical path for successful innovation. Those explorations are helping these companies innovate and grow revenue without the same approach to massive investments in scaling.

Why R&D efficiency is critical

Semiconductor companies spend more on R&D than do companies in any other industry outside pharmaceuticals—and all of it while dealing with ever-shortening product life cycles for their customers. High R&D spend is critical to their futures because current products will soon become uncompetitive, so new products are continuously needed to survive. The large amount of R&D required to maintain market position in an industry with stagnant revenues increases the pressure to get a higher return on R&D spend to drive profits.

During periods of slower revenue growth, pressured R&D budgets preclude the level of product development necessary to spur future revenue growth, which causes companies to miss major product cycles. That creates a death spiral in which a company's inability or unwillingness to fund necessary R&D programs leads to further market share erosion and greater revenue declines.

How does that downward spiral begin? When a company misses market signals and its products are not aligned with end market needs, it is likely to lose key market share or become too heavily exposed to a shrinking market. That can obviously lead to negative impacts on revenue and earnings, and a common reaction is to constrain R&D spending as part of overall retrenchment. But if that reaction is conducted carelessly or thoughtlessly, the company risks accelerating its losses through continued market share declines resulting from lack of innovation.

One of the main results of R&D efficiency is the ability to get products to market on time. For leading-edge products, when power and performance count, time to market means the difference between success and failure. Companies must not only deliver individual programs on time but also balance a portfolio of R&D resources and deliver multiple programs on

time—and do it generation after generation. The proper balance of resources is critical; even one program that goes over budget could affect the development of the next generation of products by delaying the dedication of resources to that program. Sometimes organizations take on too many programs and stretch resources too thin in an effort to capture every incremental opportunity, which can jeopardize the delivery of programs serving the core business. Without proper discipline, chasing multiple incremental opportunities can delay key programs and then snowball into multiple generations of delayed programs, which in turn can lead to market share loss and/or more aggressive discounting and pricing, again in turn leaving fewer margin dollars to fund future R&D investment.

How to improve R&D efficiency with effective portfolio management

Companies have achieved a 30% or greater increase in R&D efficiency—as measured by return on invested R&D dollars—through the implementation of proper planning processes and better allocation of resources. In turn, such improvements can lead to top-line growth through market share gains in key segments and can lower R&D costs per program through faster time to market.

Companies with poor R&D efficiency often suffer more from lack of proper planning than from inability to innovate. The areas of greatest importance are alignment of R&D investment with market needs, allocation of the proper amount of resources, and designation of sufficient financial requirements for the programs to meet. The integrated planning process for those areas also requires inputs from sales and marketing, R&D, operations, and finance. The process should capture market requirements in a specified time frame based on end-market customer feedback and should align with the R&D organization's ability to deliver based on its capabilities. Aligning R&D capabilities with opportunities from the marketing organization can enable management to create a list of potential programs the company could pursue to address market needs. After financial requirements and analysis have been provided, management can then rank the potential programs based on the company's strategic priorities and expected return on investment (ROI). Once program execution begins, management should make sure that the programs with the highest-rated priorities are fully resourced and brought to market on time.

Linkages between the marketing, R&D, and finance organizations are important in the development of a road map that aligns company strategy with the company's go-to-market approach (figure 5). The proper channels must be in place to ensure alignment of the different organizations at all key

junctions of program development and execution; this enables the organization to course correct if market forces change and impact the business case for the program. Identifying these changes early can make the difference between achieving a profitable ROI in a program and taking a substantial loss.

FIGURE 5: Developing a sustainable roadmap



Several benefits accrue from proper program planning and careful resource allocation. Delivering a predictable road map that has credibility with the customer base is critical to the maintenance and growth of market share. A road map also pinpoints the resources available for next-generation programs; such resources are necessary for keeping semiconductor companies on pace with the industry's ever-shortening product life cycles.

Other advantages, not always as apparent, are effects on pricing, supply chain complexity, and R&D operational expenses. When companies are late to market or out of alignment with market needs, they sometimes deliver products without key features and are then forced to cut selling prices. Having a planning process in place that aligns market requirements with R&D activities enables companies to reduce the likelihood of having to heavily discount their products.

Another potential benefit is the avoidance of stock-keeping-unit proliferation. (See AlixPartners publication: *Internet of Things: New Challenges and Opportunities for Semiconductor Supply Chain*.) Typically, when it becomes apparent that the core technology investment will not generate required financial returns, a company will produce variations of the platform technology to capture more revenue. Those additional offerings add substantial complexity to supply chain and manufacturing operations. And although the incremental R&D investment may seem small, the impact on other organizations could be substantial due to fully supporting a separate product offering across operations, manufacturing, and sales and marketing.

Without a proper view of portfolio profitability, it is impossible to determine the impact of a program across an entire company. With a well-developed planning process in place, the platform technology investment should succeed in capturing sufficient market share to generate required financial returns without having to chase incremental opportunities that have only marginal benefit and can risk other investments.

How to take risk out of R&D investment

Instead of bearing the entire risk of the R&D investment for important product development efforts, companies can find ways to de-risk through M&A, joint ventures, and consortia. Other than managing internal resource allocation, companies must also settle the make-versus-buy decision for key IP and product developments. A company that is effectual at analyzing its own capabilities—versus outside sources of delivering new revenue opportunities—can realize great benefits from acquiring assets that are underperforming in another environment and that could become a complement to the current portfolio—all of it while taking a potential competitor out of the market. Some companies have been extremely successful at identifying assets that would be more profitable if acquired and then integrating the assets into their portfolios. It does require a thorough internal review of portfolios and engagement with advisors to decide on potential targets.

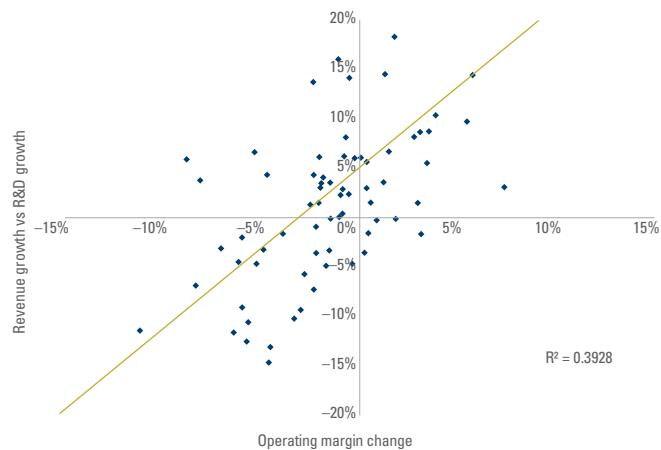
Other ways to de-risk the R&D investment are to explore the establishment of a joint venture, the use of consortiums such as IMEC or SEMATECH, or the founding of other partnerships that spread the risk across multiple parties. Intel took that approach in the area of extreme ultraviolet lithography through its investment with ASML—followed quickly by TSMC and Samsung. Many companies engage with consortia such as IMEC to ensure alignment on key early-technology milestones and with supply chain partners such as foundries and capital equipment providers.

How spending affects profitability

Though R&D is a crucial lever for maintaining competitive advantage, simply increasing R&D spend does not necessarily lead to increased revenue growth and profitability. In fact, AlixPartners' study of the 79 largest public semiconductor companies globally found no significant difference in operating margins between companies that increased R&D spend and those that maintained or reduced it. What matters more, in terms of profitability, is the relationship between spending increases and revenue increases. We have consistently seen that companies whose revenue growth exceeded their R&D spending growth outperformed their competitors by a wide

margin. Those companies saw operating margins increase 77% of the time, and their operating margin increases were twice those of companies that grew R&D spend more quickly than revenue (figure 6). The results indicate that those companies have done good jobs of implementing tools and processes that control spending and correctly allocate resources in their product development teams.

FIGURE 6: Change in operating margin vs change in R&D as % of revenue (2006–2008 vs 2012–2014)



Where to start?

Tracking investments by program and monitoring the financial results to report their actual returns on R&D investments by program can seem daunting at first. Usually, the best way to start is by determining where the company is making or losing money in its current customer and product portfolios and where it has targeted current R&D investments for future revenues. Such determinations pinpoint the strengths and weaknesses of the current portfolio and lead to better understanding the company's true potential for success with future investments. We believe the establishment of such processes and tools is central to the start of a robust planning process with proper inputs from all key organizations to ensure alignment with market needs, R&D capabilities, and financial returns.

Companies such as Intel and Texas Instruments have been very successful with the zero-based-budget (ZBB) approach to their R&D investment portfolios. We have found this approach to be widely applicable in the semiconductor industry at companies that have competing priorities for R&D resources across multiple product and customer segments. The ZBB approach ensures that the highest-priority core programs get fully resourced and are held accountable for delivering products to market at the right time and at the right performance level. The

approach has been highly successful, but it does require companies to be more disciplined in their planning processes and their uses of data.

What types of companies would benefit from the ZBB process?

Companies with large R&D investments in time-to-market critical segments: We see the most success with this approach in markets with critical needs to deliver products to market on schedule. The abilities to allocate resources to the most-critical areas, to control scope creep, and to closely manage the road map are the advantages this approach offers.

Companies with high R&D investment across segments with various growth prospects: This approach also is very useful when companies are attempting to manage R&D budgets across multiple segments when one segment is in a mature, low-growth state and the other target segments have much higher growth potential. The ZBB process helps make for transparent reallocation of funds from mature segments to higher-growth areas that require more resources but should generate a higher ROI.

What types of companies would benefit from more traditional portfolio management approaches?

ZBB is a great process, but it's not for everyone. It requires mature planning processes and a high amount of overhead to ensure that products stay on track and be able to deliver the expected ROI based on priority status in the company's portfolio. While ZBB may not be the right fit for all firms, the principles of portfolio management benefit all companies.

Companies that do not have as high an investment in R&D and that have highly diverse portfolios would not want to manage a full ZBB process. Such companies need a more traditional approach to managing their portfolios, which involves understanding the true profitability of each product and customer combination, managing the right level of overall

investment in products and segments, and controlling overheads. The approach may be traditional, but it is not commonly done well at most semiconductor companies. The high levels of consolidation and growth in product portfolios have made it very difficult for companies to manage their portfolios of products and optimize offerings to generate higher profitability. This leads to a situation wherein many companies continue to support product lines that no longer offer value to the company. Using portfolio management to make tough decisions on those products and segments can allow a company to redirect resources to areas with higher chances of adding value and further increasing return on R&D investment.

Conclusion

Even as Moore's law fails to deliver the same level of growth and profits as in the past, there is a way for semiconductor companies to continue to innovate and profit from the R&D investments they make. Companies that are effective in analyzing their portfolios and assessing their internal capabilities in R&D can greatly benefit from the industry trends by way of M&A, partnerships, or other targeted actions within their product portfolios to improve return on R&D investment. We encourage companies to take a hard look at the real performance of their portfolios and determine the levers available to get more out of their R&D investment and thus pave the way to future success either with or without Moore's law.

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