Creating Value in the Semiconductor Industry
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Introduction

Despite its moderate size, the semiconductor industry “punches above its weight,” contributing disproportionately to growth in U.S. labor productivity and delivering tremendous value to consumers. The semiconductor industry is small relative to other segments of high tech and other industries, with annual revenues of approximately $250 billion globally, but along with the electronics industry it contributed over 25% of total U.S. productivity growth—more than any other sector—when comparing the years 1995 to 1999 with 1987 to 1995.¹

Much of the tremendous growth seen in the electronics industry over the last three decades comes directly from the increasing power and decreasing price of semiconductors, a manifestation of Moore’s Law.² This performance improvement enables the electronics industry to continually produce devices and systems that are smaller, more powerful, and richer in features at lower price points. If the automotive industry, for example, had achieved similar improvements in performance over the last 30 years, a Rolls-Royce would cost only $40 and could circle the globe eight times on one gallon of gas—with a top speed of 2.4 million miles per hour.

However, most chipmakers capture only a small percentage of the tremendous value they create, with consumers being the recipients of the lion’s share. Indeed, despite its large positive impact on overall economic growth, the semiconductor industry (excluding Intel) destroyed approximately $45 billion in value for shareholders between 1996 and 2005 (Exhibit 1, overleaf).

The economic challenges that the semiconductor industry faces can be attributed to a confluence of three factors: cyclical, rising R&D costs, and rising capital costs. Underperformers have been able to stay in business because the profits they generate during a cyclical upturn enable them to sustain their operations during a downturn and attract funds for capital investments beyond market requirements, initiating the next cyclical downturn. Government interest in building semiconductor industries—most recently in China and India—accentuates this problem. Driven to meet the expectations of Moore’s Law, chipmakers invest heavily in R&D, the costs for which have risen along with the ever-increasing complexity of the chips. Similarly, the investment hurdle for building a state-of-the-art chip fabrication plant continues to rise.

Although the industry on average destroys value, several players have consistently generated a disproportionate amount of economic value—in fact, in many segments the top performer generates more than 100% of the total value. How do the top performers succeed? They focus on changing the dynamics and structure within a given segment through disruptive innovation, improved architecture, and close collaboration with top equipment manufacturers to build a leading position, rather than engaging in price wars to fight for share of a well-established space. They also proactively manage their portfolios, concentrating their investments in successful businesses in higher-growth, higher-margin segments while divesting from laggards. Finally, top performers focus on lean, world-class operations, employing best-practice techniques for efficient manufacturing, procurement, pricing, and supply chain management, and aggressively monitoring R&D investments.


² According to Gordon Moore, a founder of Intel, the number of transistors that can be fitted into a single chip doubles roughly every two years, resulting in both faster performance and lower cost.
To follow the example set by these industry leaders, we recommend that semiconductor companies take a dual approach to optimize value creation. First, they must execute operational improvement programs to optimize return on invested capital (ROIC) rather than share or gross margin, a process that entails identifying improvement levers relating to each component of ROIC and designing initiatives targeted to each. Second, they must optimize their portfolio of product lines, pruning lines with low ROIC and identifying and entering—or even creating—segments with the potential for high ROIC before they are mature. This approach has yielded impressive results, as typical improvements in ROIC are in the range of 5 percentage points, with some companies improving ROIC by as much as 20 to 30 percentage points.

The sources of value destruction

Although an analysis of income statements shows a number of profitable players in the semiconductor industry, most players are not able to generate economic profit, that is, returns above the cost of capital. Indeed, disaggregating the industry by business model and industry subsegment reveals that in most segments only one or two players create value after accounting for the cost of capital.

Why has the industry as a whole struggled to generate economic profit? As we have indicated, the answer lies with a number of factors that present unique challenges to chip manufacturers.

Historically, the semiconductor industry has shown strong cyclical behavior. During the typical upturn of one to two years, most companies generate profits, which they use to sustain their operations during the downturn. In addition, many players are able to use their strong performance during an upturn to entice investors in the public markets or get new loans to fund capital investments; in many cases, governments subsidize these refinancings. But the upturn is followed by a longer downturn or a very slow growth period, during which the poor performers struggle. There is some evidence to suggest that the amplitude and time frame of the industry’s cyclicity is moderating, but it is likely that some degree of cyclicality will remain.

The skyrocketing costs of R&D and the increasing amount of capital required to build a state-of-the-art chip fabrication plant add to the industry’s economic challenges. Chipmakers continue to pour money into R&D, as new designs and process technologies are...
increasingly expensive to develop. In 2006, R&D spending amounted to approximately 18% of industry revenue for semiconductor companies (up from 12% a decade earlier) vs. 3% for auto makers and aerospace companies. The level is expected to exceed 20% of industry revenue in the coming years. The cost of building leading-edge fabs continues to increase as well; for example, the average 8-inch fab costs $1.6 billion to build, while a state-of-the-art 12-inch fab costs $3 billion to $4 billion. Similarly, the costs for developing process technologies on new nodes is increasing dramatically; for example, the average cost of developing a 90nm logic process technology is approximately $300 million, while the cost of developing a 45nm logic process technology is approximately $600 million, representing a doubling of spend.

In response to these higher costs, many semiconductor companies have resorted to “fab-lite” strategies, in which an increasingly large fraction of their chip production is outsourced to dedicated manufacturing foundries. Although this has resulted in an overall net reduction of capital expenditures in the industry, from an average of approximately 27% of revenues (for the period 1996 to 2001) to approximately 20% of revenues (for the period 2002 to 2010 (forecast)), it has also led to intense cost pressure on chipmakers that continue to handle all of their manufacturing in-house (Exhibit 2). The shift of manufacturing to Asia has created additional cost pressures on those that have yet to transfer operations to lower-cost locations.

Prices also remain under pressure in the industry, as consumer applications become the main force driving the semiconductor market. The much higher elasticity of demand as prices decline has further accelerated the erosion of average selling prices. These pressures are intensified by the shift in the end-user market to Asia. Furthermore, the lack of a “killer app” on the horizon – and the slower growth of traditional large, high-growth markets such as PCs and mobile phones – means that the economic pressures on the industry are not likely to abate any time soon.

Exhibit 2
Capital spending as a percentage of industry revenue is declining, even though capital costs are increasing

- **Forecast**
- **LITHO TOOL EXAMPLE**

Sources: IC Insights; WSTS
Learning from the top performers

Despite the pervasive value destruction in the semiconductor industry, a handful of players have consistently generated a disproportionate amount of economic value. An analysis of the key attributes of these companies, as well as those of the other leading players, suggests three major lessons for players seeking to capture economic profits in the semiconductor industry.

First, rather than engaging in price wars, top performers focus on changing the dynamics and structure within a given segment as they seek to build leading positions early on. Acquiring and holding a market share of 40% or more within a segment enables companies to drive higher profits by gaining a competitive advantage over other players (Exhibit 3). These companies typically have closer relationships with key customers; innovation road maps that are more advanced and more aligned with the key value drivers for their segment; better insights derived from having a more complete picture of where the market is going; and, in many cases, an ability to maintain margins through downturns.

For example, TSMC’s high market share in the foundry industry, established early on by creating a new business model, gives it a technical edge that stems from its special insight into the needs of leading customers, provides more stable demand through protection from fluctuations in individual segments and customers, and gives better returns on capital by allowing it to amortize across a large customer base. Intel’s lead in the microprocessor business allows it to set the rate of technological innovation and node migration and enables its “platformization” strategy (i.e., selling collections of chips under brand names, such as the Centrino chipset).

In pursuing market share within a segment, it is critical for companies to avoid the price wars that so often destroy value in mature markets. The quest for market share that creates value is an insight-driven process that entails seizing an opportunity to shape a new space. To do this, top performers partner with systems-level companies to develop innovative designs or multimedia capabilities that create value through the growth of a new market space. This requires disciplined processes for screening emerging applications and potential partners to identify those most likely to succeed, and making bets with the customers best positioned to develop promising applications. For example, as demand for advanced medical devices and biotechnology increases over the next 10 years to serve the needs of an aging population, chipmakers have an opportunity to partner with device manufacturers and biotech companies to develop applications for sensors and implantable devices. Similarly, the Wii, iPhone, and antilock braking systems in cars have only begun to demonstrate the broad new applicability of MEMS technologies. While these markets...
are currently small, they are likely to grow significantly, offering the opportunity for a semiconductor player to gain a dominant market share.

Second, leading chipmakers proactively manage their portfolios, investing in market segments that are growing, either organically or through acquisition, and divesting from segments for which growth or margins are low. In reviewing its portfolio, a company may find that it includes some fast-growing businesses with high profit margins as well as other businesses in which the company has achieved limited success despite years of investment. Top-performing companies recognize that portfolios should evolve as markets mature or become less attractive. Rather than engaging in a price war to increase their share of a stagnating market, for example, they drop out of businesses that offer little hope of profitability.

Several top performers have been particularly successful with this approach. Texas Instruments has divested more than 15 lower-growth, lower-margin businesses in the past 15 years (e.g., DRAM, defense, controls) to focus on the wireless business as well as developing a medical business. Qualcomm focuses on the large, high-growth wireless handset market and, by controlling intellectual property, is able to generate significant profits through licensing arrangements with an ecosystem of partners, creating an additional revenue stream that does not entail building chips. Applied Materials’ ability to enter key new growth segments (e.g., RTP, copper deposition, solar), while exiting underperforming segments (e.g., implant), has enabled it to maximize profitability.

Third, the industry’s top performers focus on lean, world-class operations. While companies in cyclical industries typically seek to reduce costs during a downturn, outperformers focus on operational efficiency and costs regardless of where the industry is in its cycle. These companies employ techniques used in lean manufacturing to increase ROIC while reducing lead time and inventory holdings. Top-performing companies also excel at supply chain management to reduce inventory levels, establish a flexible approach to manufacturing to reduce risk, and strictly monitor R&D to increase returns. For example, TSMC leads the foundry industry in part because of operational efficiencies, including fewer defects, higher yields, shorter cycle times, and higher overall equipment effectiveness (OEE) – a measure of how well manufacturing equipment is running relative to the ideal plant. Samsung’s operational excellence in memory manufacturing has enabled it to remain profitable in a commodity business by ensuring an industry-leading cost position. The payoff from a lean transformation can be substantial: One client enjoyed a nearly 20% increase in gross margin following a series of lean transformation initiatives.

### The winning moves

To join the ranks of the industry leaders, we recommend that semiconductor companies follow a dual strategy to maximize value creation (Exhibit 4, overleaf). First, companies must optimize ROIC by executing operational improvement programs to target profitability and capital turns, and defining their asset strategy (make vs. buy) to further improve capital turns. To target areas for improvement, a detailed “ROIC tree” can be used to disaggregate the components of revenue, cost, and invested capital and identify the main value-creation levers for each component. Exhibit 4 lists examples of value-creation levers and the impact that companies have achieved.

For example, we have helped more than 10 semiconductor companies across the globe increase the throughput of their fabs by 20% to 30% (with minimal additional capital), which has been a significant driver of incremental gross margin and ROIC. These gains have been achieved by maximizing OEE, a technique that exposes all the losses attributable to a bottleneck machine in a 24-hour period, thereby allowing companies to focus on reducing the largest losses. This technique was as effective in 4-inch, 5-inch, 6-inch, and 8-inch fabs (the older, trailing-edge fabs) as it was when deployed in leading-edge 12-inch fabs.

In trailing-edge fabs, most of the improvements are captured from increasing the uptime of bottleneck machines, for example, by minimizing machine changeovers and setups and optimizing material handling to ensure that a bottleneck machine is never left idle. By contrast, in leading-edge fabs,
many of the improvements come from reducing the process time of an individual wafer by tailoring the sequence of tasks of the bottleneck machine to a specific "recipe" (the unique flow of manufacturing process steps required to fabricate the wafer) and eliminating redundant processes. For example, dielectric thin-film deposition times can be decreased, with a corresponding increase in the throughput of deposition equipment, by reducing the thickness of excess dielectric material. This has the added benefits of increasing both the throughput of CMP machines (because less excess material is removed in the polishing process) and the lifetime of the CMP pads.

As another example, we have helped semiconductor companies use both value-based pricing and transactional pricing to drive revenue increases of 2% to 7%. Value-based pricing enables companies to set prices that are equivalent to the value perceived by customers. This is done by identifying the individual value drivers of a product; interviewing customers to understand the importance of each of these drivers to their purchasing decisions; understanding the degree of differentiation the company has when measured against each driver; and translating this value into price. Transactional pricing, by contrast, focuses on minimizing the leakage of value in the final price relative to the list price. This leakage is analyzed in terms of "variance" (differences in discounting or margin performance), "slippage" (deviations from established policies, guidelines, or programs), and "structure" (subopti-
mal pricing structures, processes, or delegation levels, resulting in unnecessarily low net price levels).

Next, companies should seek to optimize their overall portfolio of product lines, eliminating product lines with low ROIC or growth rates and entering new segments with high ROIC and growth rates. Products with low ROIC are those that have returns below the weighted average cost of capital and therefore destroy value. Because of the complexity of determining the ROIC of individual products and product lines, it is often sufficient to use gross margin and growth potential as a proxy.

Using this methodology, top performers segment their existing portfolio into “stars” (high gross margin and high-growth product lines), “cash cows” (product lines with high gross margin but low growth potential), “question marks” (product lines with high gross margin and growth potential that are currently underperforming), and “dogs” (products whose gross margin and growth potential are too low to create value and should therefore be culled). For example, at one company, managers of the product lines in the question-marks category are given 90 days to present a plan to move the product line into the stars or cash-cows category, or have it culled as one of the dogs. Top performers undertake this portfolio management process at least annually as part of the strategic-planning cycle.

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The inability of many semiconductor companies to create value is one of the key factors driving the consolidation occurring throughout the industry’s value chain today. Indeed, as private-equity players set their sights on the semiconductor industry, underperforming companies are faced with a stark choice: They can either follow the lead of top performers and undertake initiatives to improve performance and become a shaper of the future industry structure, or they can leave it to acquirers to step in and drive a new dynamic of value creation. Those that choose the former course must begin by evaluating whether they have the strategic, organizational, and operational capabilities to pursue a performance transformation, and must take steps to close capability gaps before embarking on the journey.

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