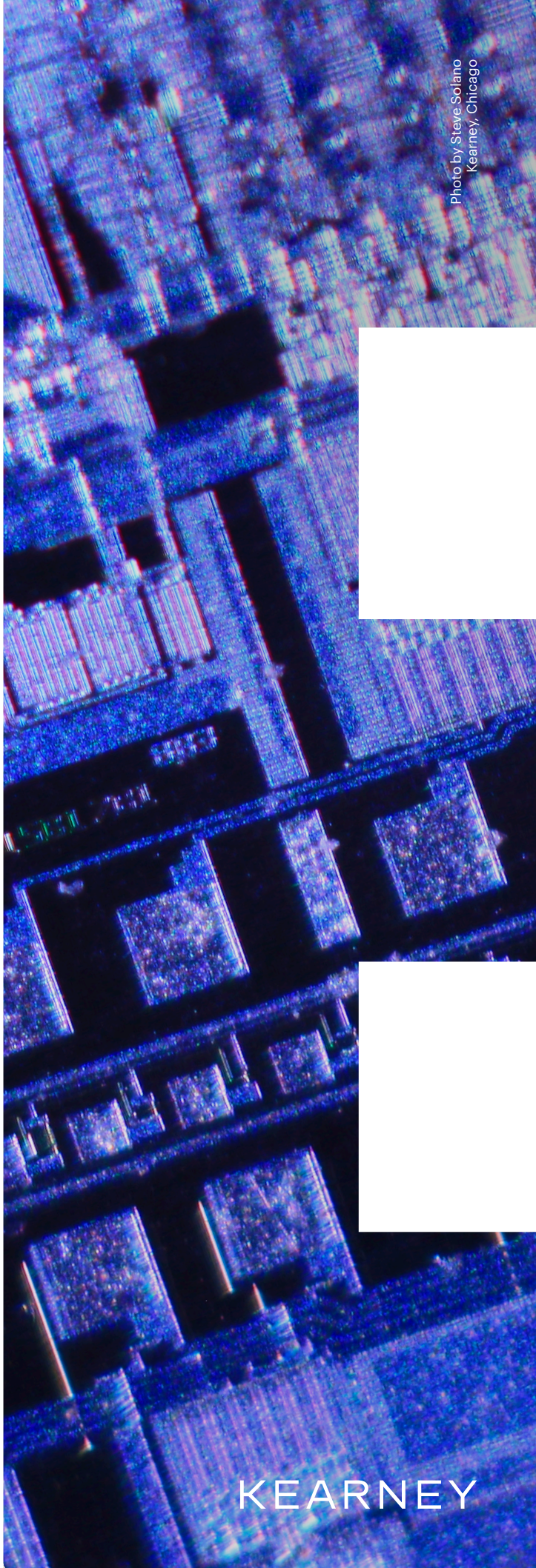
Shoring up the semiconductor supply chain



KEARNEY

Given the explosion of complexity in the industry, chip manufacturers that revamp their supply chains can create a powerful and sustainable competitive advantage.

The semiconductor industry is at the heart of technological advancements, driving innovation across a variety of sectors, from consumer electronics to autonomous vehicles and artificial intelligence. As the demand for smaller, faster, and more efficient semiconductor devices continues to grow, semiconductor fabs face unprecedented challenges and opportunities. A crucial aspect of their success is a well-optimized and resilient supply chain.

In this article, we explore three areas for semiconductor fabs to consider in mapping out the best path to success:

— The industry's biggest trends, both old (such as the cyclical nature) and new (such as demand diversity and geopolitics)

— How these trends will impact fab operations

— How semiconductor manufacturers will need to revamp their supply chains, particularly in their relationships with both customers and suppliers

The supply chain rollercoaster

In the middle of 2022, chip demand was far beyond capacity, and as a result, the industry lost an estimated $1 trillion in output—more than $200 billion of which was in the automotive sector alone. That year, at SEMICON West, we asked three questions:

— Do you think the situation will change in the next 12 months? (Most people thought it would.)

— Will it change because of more capacity coming online? (Only a few people raised their hands.)

— Will it change because demand will come down? (Most people raised their hands.)

This is the nature of the semiconductor industry: cycles of over-demand and over-capacity. And through 2023 and early 2024, we have been in an overcapacity situation. For manufacturers, this becomes even more complicated when they look at their individual fabs: some remain tight for capacity while others are underutilized. The industry will bounce back, but figuring out when and how fast can be quite a challenge.

Diversity of demand

A change is happening in the mix of applications for semiconductors. The industry still relies on smartphones and personal computers, with the Semiconductor Industry Association estimating that more than 60 percent of demand will come from those two segments. Demand decline in these segments is in large part responsible for the current overcapacity situation. But demand is increasing in emerging areas such automotive, data centers, and aerospace and defense. In fact, automotive-related semiconductors have an almost 30 percent growth rate. Many companies are looking at this diverse demand to fuel the recovery and potentially smooth out some of the dips in the future.

Semiconductor fabs are facing unprecedented challenges and opportunities.

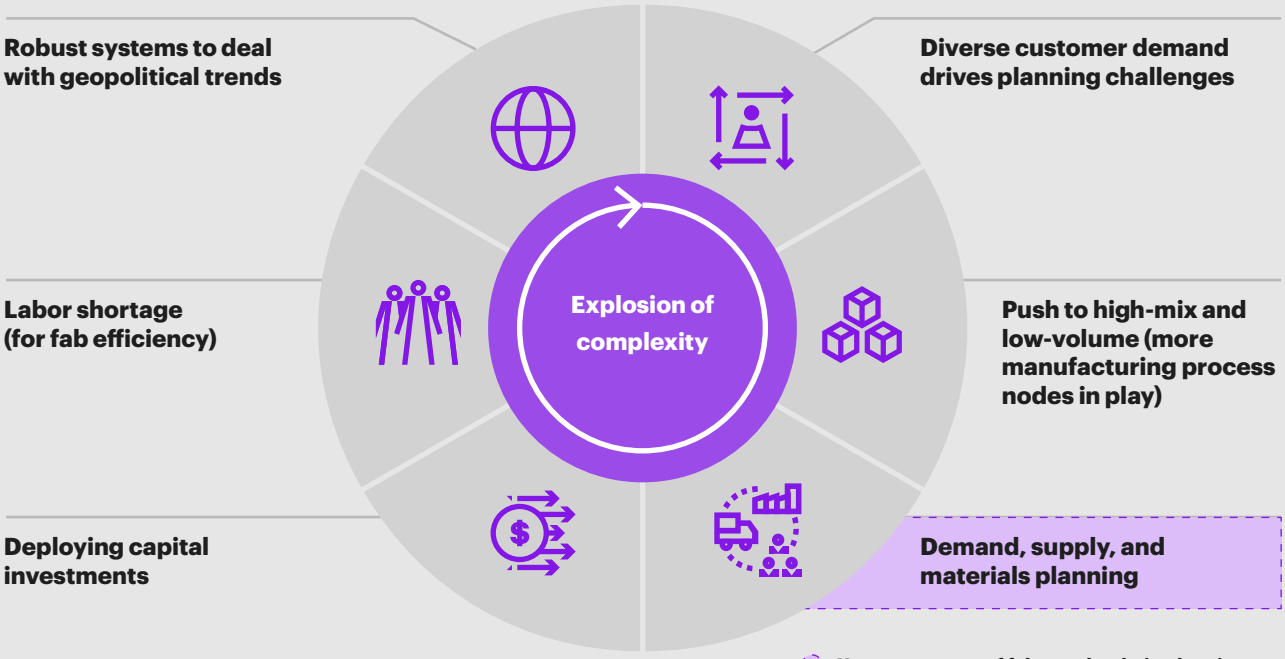
Other dynamics

Electronics are everywhere, and it's fueling the need for more functionality in a smaller and smaller footprint. In the past, this integration was achieved through technology scaling, also known as Moore's Law. For the most part, processors and memory are still able to use technology scale for increased performance, lower costs, and better power dissipation. But now, not all functions—for example, support chips such as radio frequency, power semiconductors, and sensors—can take advantage of technology scaling. We now have basically two semiconductor industries: one on the leading edge and one on the lagging edge. And each has its own complexities and investment challenges (see figure 1).

To achieve the necessary levels of system integration, chips built with different technologies are combined in a single package—hence the term system-in-package (SiP). These packages are becoming more complex; software design and simulation tools previously used for complex system-on-chips (SoCs) are now being used for SiP development.

The semiconductor industry has long benefited from global optimization of its supply chain from product design to manufacturing and assembly. With semiconductors playing an increasingly crucial role in sensitive infrastructure areas such as AI, 5G, and defense, the political pressures have pushed more countries and regions to consider onshoring parts of the supply chain, particularly fab manufacturing. The United States has started the award stage for funding from the $52 billion CHIPS and Science Act. Similar activities are happening in Singapore, South Korea, France, and Germany.

Figure 1
What does this mean for fab operations?



Source: Kearney analysis

The impact on fab operations

So what are these complications doing to fab operations? Forecasting, demand planning, and capacity investments can be very tricky, particularly during inflection points of the cycles. Compounding this is the fact that customers will accelerate new product launches, often in new manufacturing technology nodes, to gain or maintain a competitive edge coming out of downcycles. Accurate demand forecasting is pivotal in preventing overproduction or underproduction. Semiconductor fabs can use advanced data analytics, machine learning, and AI to forecast demand trends. Managing inventory efficiently is equally important as excessive inventory ties up capital and can lead to obsolescence, while insufficient inventory can cause production disruptions. Just-in-time inventory strategies can help strike the right balance.

These emerging industries create new technology requirements for areas such as functional safety, reliability, and broader operating environments. Manufacturers will have to develop a combination of manufacturing and inventory strategies to deal with life cycles that could approach 20 years. All this typically means keeping more technologies active and having to support more part numbers. Even business models are changing, with many new users of semiconductors looking to vertical integration: doing their own chip designs and interacting directly with foundries to differentiate, save money, and gain more control over their supply chains. There is precedent for this vertical integration, particularly in the smartphone market where many of the top original equipment manufacturers (OEMs) are doing their own chip designs. The direct interaction will also drive closer integration of digital processes between OEM customers and foundries as they implement the concept of end-to-end digital threads. Materials planning for items such as chemicals, gases, and rare earth minerals becomes more difficult.

This focus on semiconductors is creating a renewed need for skills and talents. By 2030, it is estimated that one million additional skilled workers will be needed. Corporations have started to work with universities to develop programs and training to produce a pipeline of much-needed resources for this growth. But it will take time, and the industry will have to adapt for fabs of the future—incorporating AI, analytics, and software skills.

This deglobalization will likely have some negative consequences, such as higher costs and more difficulties for planning materials such as chemical, gases, and rare earth minerals. Countries will have to come face to face with some of the sustainability challenges of semiconductor manufacturing, including the need for large amounts of water and energy and dealing with toxic materials, chemicals, and gases.

The state for fabs today and tomorrow

Many areas have gaps that prevent fabs operations from achieving their planning goals, including forecast modeling, demand planning, supplier relationship management (SRM), parts and material planning, inventory management, and production execution. All of these areas are suffering from a lack of accurate projection, easy flexibility for optimization, and nimble change management. Although important topics, inventory management and production execution are beyond the scope of this article. Here, we focus on items related to relationships with customers (forecast and demand planning) and suppliers (relationship management as well as parts and material planning).

Accurate forecasting and demand planning can reduce procurement and sales, general, and administrative spending by double digits. The key is for manufacturers to develop their own statistical models based on internal and external sources of data. This includes the latest market trends, customer sentiments, competitors (both the manufacturer's competitors and the customer's competitors), product road maps, and customer-independent supply chain data. These sources of data allow manufacturers to perform customer-independent model runs and prevent commitments that diverge vastly from current market conditions. Output from these models can include least optimistic, most probable, and most optimistic to provide a range of likely demand for operational sensitivity planning. This is essential for product efficiency as well as investment decisions related to strategic and commercial planning (see figure 2 on page 4).

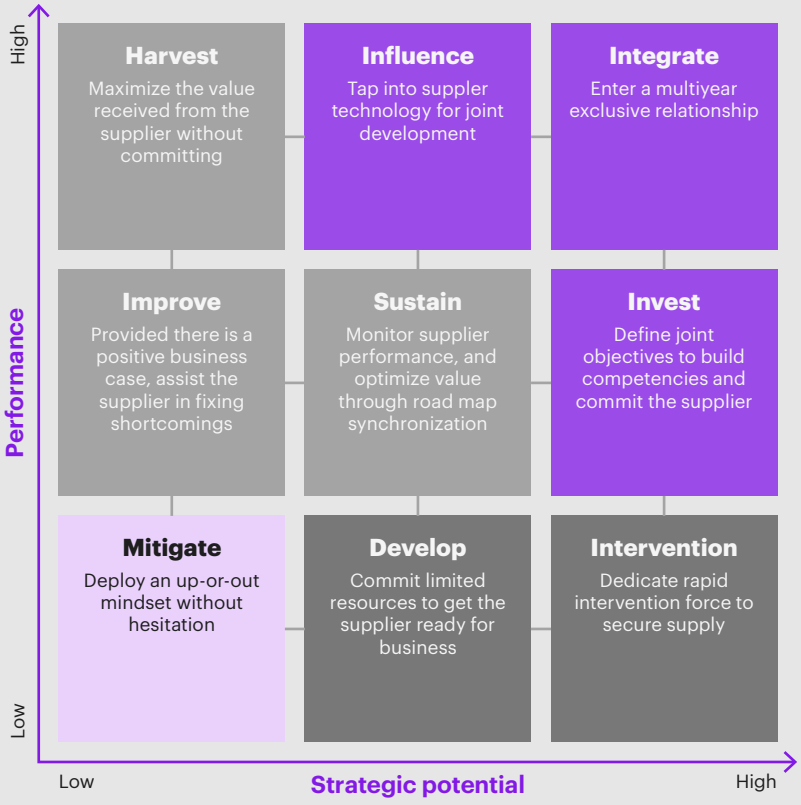
Semiconductor fabs must diversify their supplier base geographically to mitigate the risks associated with relying on critical materials and components from just one region. Building strong relationships with suppliers and fostering collaboration is crucial. Semiconductor manufacturing hinges on a complex network of suppliers, including those providing raw materials, equipment, and software. Close collaboration can lead to early access to cutting-edge technologies, reduced lead times, and improved cost-efficiency. Moreover, collaboration can facilitate joint research and development efforts, enhancing product quality and innovation.

Figure 2

Recognizing the critical suppliers that are worth significant time and attention is essential to supplier relationships

Key supplier interaction models by segment (Kearney TRUE^{SRM})

- Prioritize suppliers
- Status quo: maintain relationship
- Immediate action needed to sustain relationship
- Bail out of the relationship



Source: Kearney analysis

Pinpointing the suppliers that are worth significant time and attention is essential to supplier relationship management. High-performance suppliers with long-term strategic potential are worth engaging in multiyear exclusive relationships. Lower-performing suppliers with little strategic potential should be either managed toward improvement or rapidly dropped. Managing suppliers needs to be done in conjunction with a materials consumption approach. Many manufacturers have a number of fabs that operate independently, sometimes as a result of mergers or acquisitions, which can lead to different bill of materials (BOM) and even different practices for what is tracked in the BOM and what isn't. A comprehensive BOM standardized across all fabs, including for early prototyping and new production introduction, creates a complete view of material consumption, which optimizes the material requirements planning process, including the materials outlook, vendor ordering, and inventory hold.

As environmental and ethical concerns become more prominent, semiconductor fabs must consider the sustainability of their supply chain operations, including focusing on responsible sourcing of raw materials, reducing carbon emissions, and minimizing waste. Forward-thinking fabs work toward a circular economy by recycling and reusing materials wherever possible. Ethical considerations extend to labor practices and ensuring fair working conditions throughout the supply chain. The semiconductor industry operates in a highly regulated environment, subject to various international, national, and regional regulations. Fabs must stay informed about changing regulatory requirements and ensure compliance throughout their supply chain. Non-compliance can lead to legal issues, fines, and reputational damage.

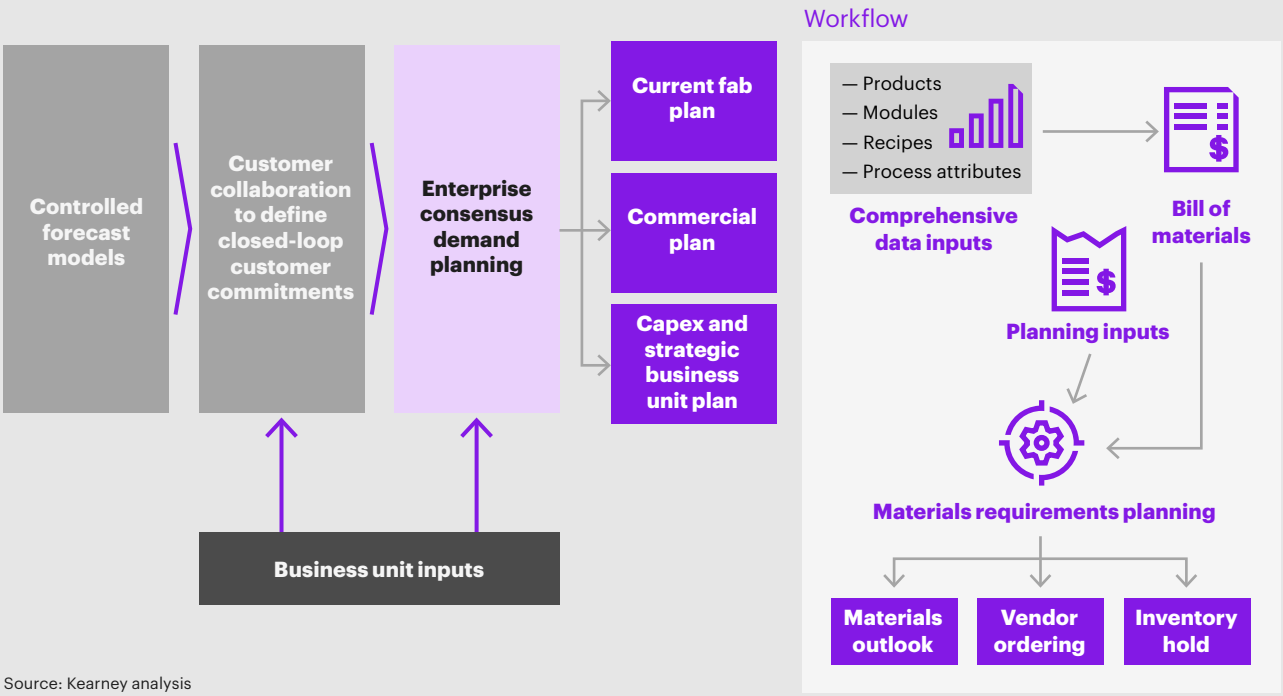
Key takeaways

Opportunities abound for semiconductor manufacturers that can properly address time-to-market pressures combined with the explosion of complexity. Fab supply chains will need to operate with nuanced inputs beyond direct customer product demand expectations, using closed-loop customer commitments and mutual collaboration to prevent inventory blowups (see figure 3). This will require manufacturer driven independent forecast models to run across various scenarios to balance raw customer input. A materials consumption analysis, combined with a comprehensive BOM across all fabs and interlocked with a strategic and performance view of supplier management, is also critical for optimizing the parts and materials process.

Semiconductor fabs can position themselves for success in an ever-evolving industry by emphasizing global supply chain resilience, building strong supplier relationships, enhancing demand forecasting and inventory management, embracing technology and process agility, considering environmental and ethical factors, prioritizing cybersecurity, and ensuring regulatory compliance. The ability to navigate these areas will be instrumental in shaping the future of semiconductor manufacturing and innovation.

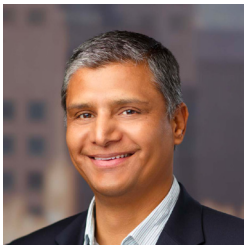
Figure 3

Consensus demand planning based on customer collaboration leads to more efficient supply-chain decision-making



Source: Kearney analysis

Authors



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