A Series of Unforeseen Events

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The popular collection of children's novels titled *A Series of Unfortunate Events* were written between 1999 and 2005 by American author Daniel Handler under the pen name Lemony Snicket. The books were adapted into a full-length feature film in 2004 and have since made their way into households around the world through the television, video games, board games, card games and audio books. The novels follow the turbulent lives of Violet, Klaus, and Sunny Baudelaire as they navigate the idyllic innocence of childhood to the moral complexity of maturity, often facing unfortunate and unexpected moments that constantly reshape their worldviews.

One of the unexpected, world-defining events of the past year has been the global shortage of semiconductor chips. While a lot of attention has been rightly focused on the recent impact to the auto industry – where automakers have been unable to finish new car builds due to a lack of chip supply – the shortage has raised concerns in many other industries as well. As Glenn O'Donnell, VP of Research at Forrester wrote, "If it has a plug or a battery, it is probably full of chips. The wireless community, industrial, aerospace, military—anyone or everyone whose products require semiconductor chips is facing a shortage."

Many point to the Covid-19 pandemic as the main perpetrator of this shortage. However, the nearly year-and-a-half long pandemic is only partially to blame. Last March, the pandemic prompted chip factories to shut down in the US and abroad. At the same time, demand for electronics and connected devices shot through the roof as people spent more time on semiconductor-reliant devices. By the time idle factories reopened, chipmakers faced a large backlog of orders – but the series of unforeseen events didn't stop there. Trade sanctions, poor supply chain planning, and natural disasters created further strains on production while demand continued to rise, pushing up prices in the process (see To Be, Or Not To Be, Transitory) on downstream products that require these chips. In other words, what seemed to be an idyllic environment for producers of planes, trains, and automobiles–not to mention most other durable goods–suddenly became a much more complex and turbulent world.

Earlier this month, Gartner analysts said they expect the worldwide "semi" shortage will last until the second quarter of 2022, which spells bad news for anyone in the market for things like new cars. In

late-May, Jeffrey Gundlach, the "King of Bonds" spoke about the shortage, stating: "I actually bought a (used) truck a couple of weeks ago and the lot at the large car dealership had no new trucks. There weren't any." Goldman Sachs paints a rosier outlook, recently stating that disruptions should diminish in the second half of 2021.

Regardless of how long the current chip crisis persists, in the midst of the chip shortage, chipmakers appear to be ramping up production capacity to meet current and future demand. For example, Intel recently announced it plans to invest $20 billion in two new factories in Arizona. Taiwan Semiconductor Manufacturing also announced plans to build a plant in Arizona and has committed to spending $100 billion over the next three years to expand its capacity worldwide.

As such, the question becomes, will this ramp in production and capacity lead to the reversal of the present problem? In other words, will shortage concerns today become overcapacity concerns tomorrow?

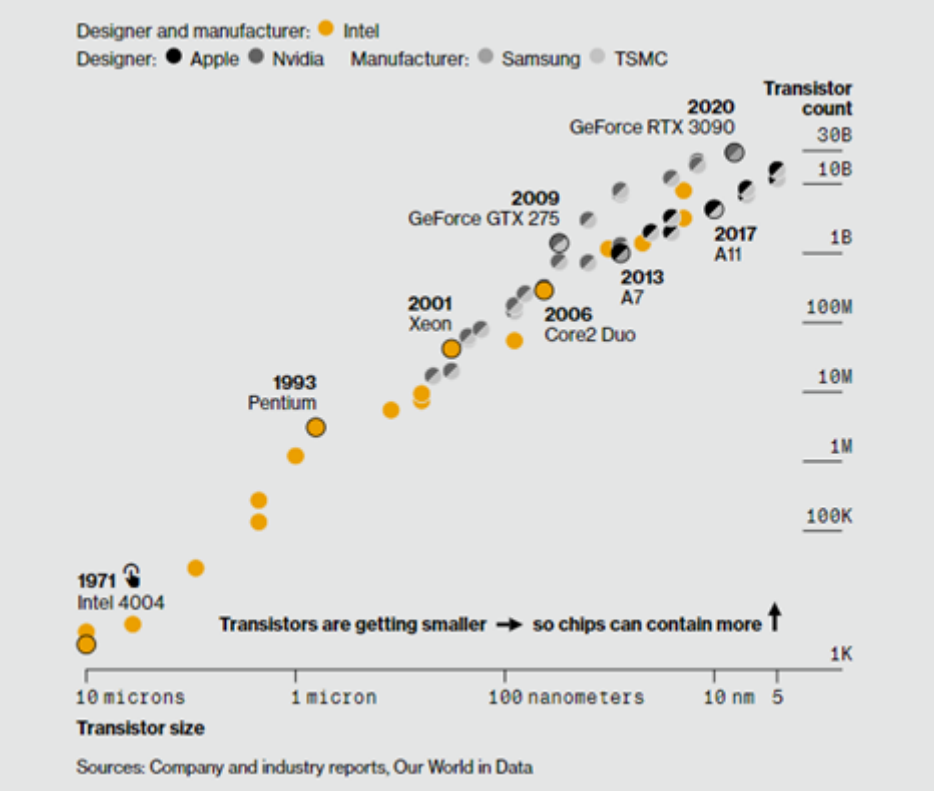
In short, we believe the answer is yes, but the macro and geopolitical forces at play complicate this answer beyond basic supply and demand logic.

The US-China Effect

As we've noted in past newsletters, US-China trade and technology tensions have created a race for self-sufficiency on national security grounds. This has trickled into a race to claim dominance in everything from tech, to telecommunications, to defense, and even the new space race. Semiconductor chips are a crucial aspect of this race, as anything that's computerized or uses radio waves relies heavily on semis (as they are often referred to), which are extremely hard to manufacture.

One of the inside jokes in the industry goes: "It's not rocket science—it's much more difficult." Former Intel boss Craig Barrett called his company's microprocessors "the most complicated devices ever made by man." Manufacturing these chips typically takes over three months and requires expensive factories, machinery, molten tins and lasers. Each room must be completely dust-free, with an end goal of transforming wafers of silicon—an element extracted from plain sand—into a network of billions of tiny switches called transistors that form the basis of the circuitry for computerized devices.

In the early days of the industry, Intel was the dominant player, giving the United States a key advantage in the processing and distribution of these critical chips. However, as new companies have emerged and packed more transistors into each chip, the once-dominant leader ceded its supremacy to countries in East Asia that started manufacturing chips with more transistors.

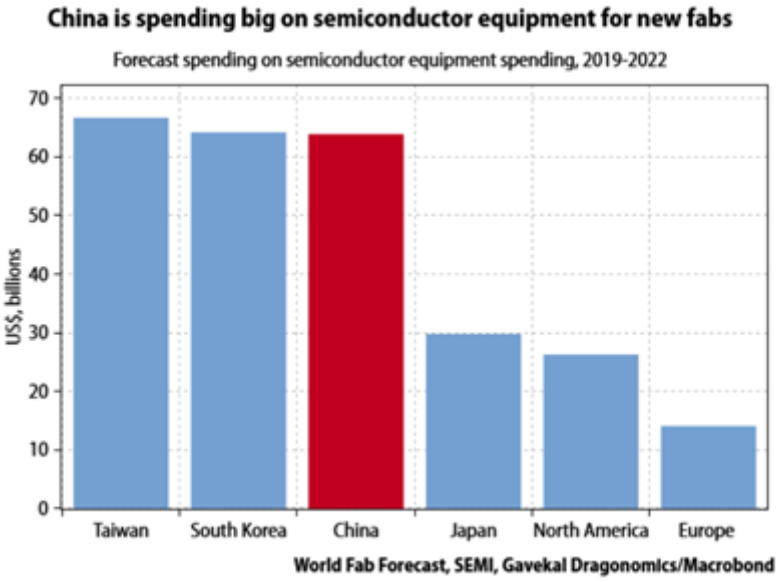


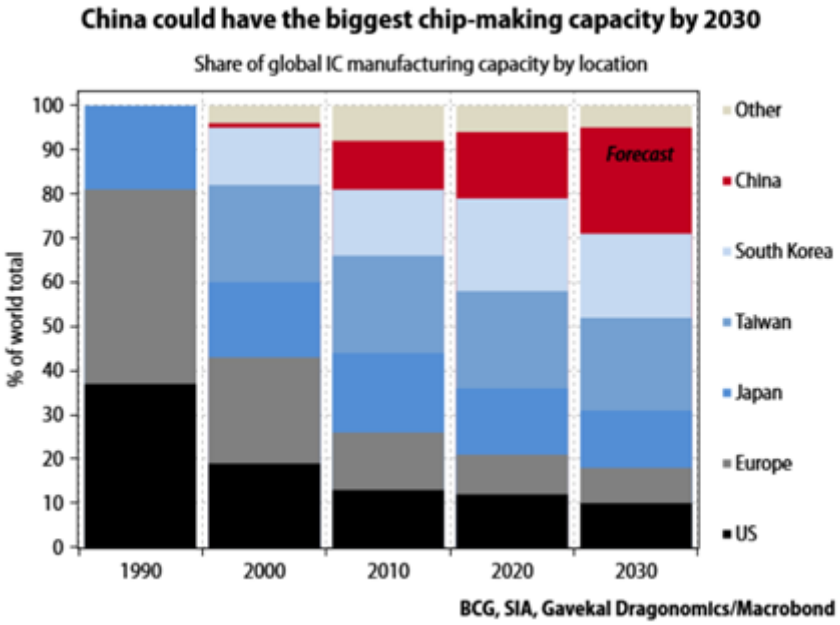
One of the predominant players in today's integrated circuit (IC) industry is Taiwan Semiconductor Manufacturing (TSMC), which is headquartered on a small island, once known as Formosa, separated from China by the Taiwan Strait, a mere 110 miles from the mainland.

Taiwan has been governed independently of China since 1949, but Beijing views the island as part of its territory and has vowed to eventually "unify" Taiwan with the mainland. With tensions continually rising, many fear that any conflict between the US and China will eventually engulf Taiwan. Which brings us back to the importance of who is leading the semiconductor race…

Beijing began ramping up efforts to gain momentum in the semi industry in 2014 with massive financial support, coordinated policies, and investments by local governments. So far, China has not developed chips that compete on the same playing field as its Taiwanese or North American rivals like Intel and

Nvidia, along with the UK's Arm, Limited (whose technology has become essential to the world's IT ecosystem). But, as the chart below shows, China is spending big on semiconductor equipment and could have the largest chip-making capabilities by 2030.

- 

- 

As tensions between China and the US grow, US government officials have taken note and advanced their own strategic initiatives. In 2020, Congress passed the CHIPS Act which authorized roughly $50B in federal funds for semi production and research over the next ten years. However, despite the

spending campaigns by both the United States and China, the small island country of Taiwan still holds the proverbial keys to the kingdom in the race to produce the most advanced chipsets.

Technological Wonder or Commoditized Product?

There's no debating the importance of semiconductor chips in today's economy; these tiny microprocessors are the driving force behind today's most vital hardware and infrastructure. However, while a select few companies and countries have taken unquestioned leadership in the space, physical limitations will likely cap future technological innovations. As our esteemed colleague at Gavekal, Dan Wang, recently wrote:

"Moore's Law—the tendency for transistor density to double every 24 months—could soon come to an end. TSMC, the world's most advanced chip firm, now produces chips at the 7-nanometer process node. Once it gets down to 2 nanometers, further progress will be highly technically challenging, since this would require manipulating materials on an atomic scale at which quantum effects become increasingly intrusive. In part for this reason, the International Technology Roadmap for Semiconductors—the global industry's consensus technical forecast—decided in 2016 that it can no longer attempt to map out targets beyond 2030."

As a result, the industry is likely heading towards a reversal of fates:

- Moving from shortage to overcapacity concerns as chipmakers in the US, China, and Taiwan ramp up production and capacity.
- Diminishing returns on new investments as physical constraints limit technological innovations.
- Decreased demand for advanced chips and increased demand for lower-end chips.

What's unclear is how quickly Chinese chipmakers can narrow the technological gap between leading chipmakers in Taiwan and North America. Failure to do so will require at least some reliance on its foreign rivals to supply it with leading chipsets that are necessary for advanced computers, devices, defense systems, etc. China's Belt and Road Initiative hinges on access to these critical components, putting neighboring Taiwan – which currently controls one of the world's most important resources – in the middle of a very messy geopolitical situation.

To wrap things up, semiconductor chips will continue to be vital components for computerized devices

used by consumers, enterprises, and governments. However, scarcity concerns today will likely become oversupply concerns tomorrow as chipmakers across the globe ramp up capacity and production efforts. The geopolitical forces between the US, China, and Taiwan will be an important story to watch as leading countries vie for access to the most advanced chipsets. But, with physical limitations on future semiconductor advancements, chips will likely change from being a technological wonder to a commoditized product in the future. It's reasonable to wonder if this will aid China over time in today's hi-tech arms race.

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any given time.