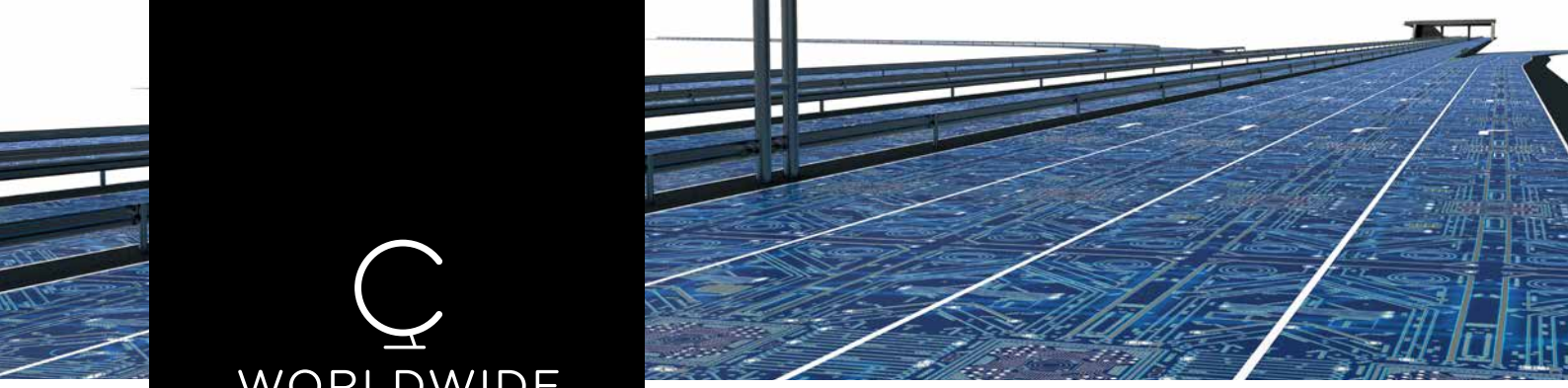

WORLDWIDE
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INSIGHT

The butterfly effect and Taiwan as the future IT hotspot

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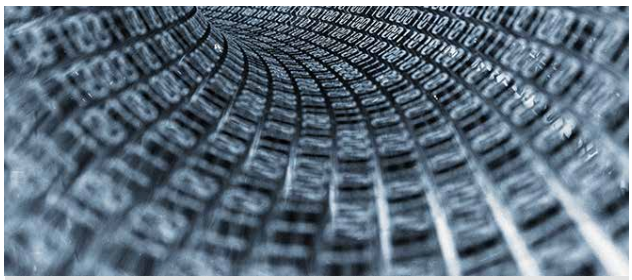
Key takeaways

- Many industry experts have prophesied that Moore's Law's days and thus the exponential growth in computing power are numbered.
- In July 2020, Intel announced that they were considering outsourcing production of the next generation of semiconductors. With this move, the company could potentially be abandoning any future pursuit of Moore's Law.
- Taiwan has become the world's largest manufacturer of semiconductors and will become the 'hottest hotspot' from a geopolitical perspective.

Over the last half a century, Moore's Law has been a key force driving global economic growth. Through prosperous times as well as times of instability, characterised by recession and political turbulence, Moore's Law (see fact box) has been an underlying factor of this economic progress. It has given us cheaper and better PCs and smartphones. Moreover, it has enabled the development of both the internet and countless new business models. The smartphones that most of us now own are vastly more powerful than the world's largest computer was 30 years ago. If it had been possible to make a mobile phone in 1991 as powerful as today's iPhone XS, the cost of the basic components and chips would have amounted to around USD 28 million. The fact that you can buy a smartphone today for around USD 1,000 is thanks to the forces of Moore's Law.

In recent years, many industry experts have prophesied that Moore's Law's days are numbered. This is because it is no longer physically possible to reduce the distances between the transistors as they approach the size of atoms. The curve will thus begin to flatten, as illustrated by the graph on the following page. This assessment was

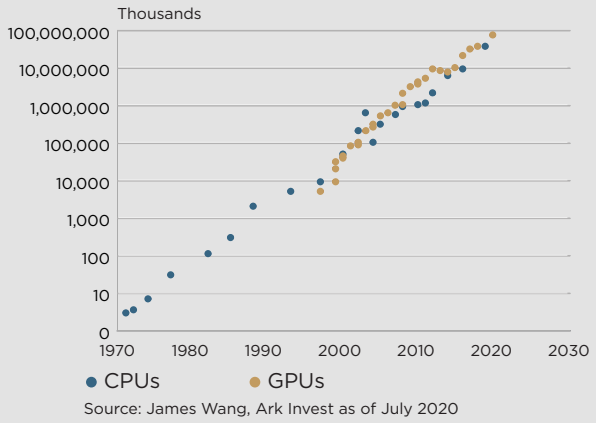


Moore's Law

Moore's Law states that the number of transistors on a chip doubles approximately every two years. This means that progress in transistors and, subsequently, computing power increases exponentially.

reinforced in July 2020 when Intel – which has been a market leader driving Moore's Law since the 1970s – threw in the towel after six years with intensifying challenges. Intel announced that they were considering outsourcing production of the next generation of semiconductors (7- nanometres). With this move, the company would be abandoning any future pursuit of Moore's Law.

Figure 1: Transistor Count



Source: James Wang, Ark Invest as of July 2020

In the early days of the semiconductor industry, chips were designed and produced by the same company. However, only a handful of manufacturers, like Intel, stuck to this strategy over the decades until today. As far back as the 1980s, chip manufacturers began separating design from production. Specialisation made it possible for manufacturers to focus on developing new ways to push the physical limits and thereby keep Moore's Law alive. At the same time, a much larger number of tech companies were able to concentrate on designing chips for a staggering number of new products, including PCs, consoles, smartphones and networks. Today, two of the most advanced leading-edge chips were designed by a 'video game company' and an 'e-commerce company' . The Nvidia A100 chip, which has 54 billion transistors, and the Amazon Graviton 2 chip, with 30 billion transistors, were both designed by American companies, but produced by TSMC (Taiwan Semiconductor Manufacturing Company). TSMC's 7 nm process, the smallest ever functional size for chips, has a distance between transistors which is less than the thickness of a cell membrane – or 1/10.000th the width of a human hair. In comparison, Intel's first microprocessor built in 1971 held 2,300 transistors and had a transistor width of 10 microns – about the same thickness as a human hair.

The semiconductor industry has seen significant consolidation over the years. In 2001, nearly 30 semiconductor manufacturers produced leading-edge chips. Today, there are only three manufacturers: TSMC, Samsung and Intel. Even though American tech companies design 65% of the world's chip volume, Intel is the only US company that designs and manufactures leading-edge chips. And now, Intel has announced that the company is considering giving up . The significance of this decision cannot be underestimated, due to the industrial and geopolitical implications and because it shows how complex continued technical progress and subsequently economic growth have become.

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CPU or "Central Processing Unit" is commonly known as a processor. It performs all the calculations in a computer.

GPU stands for "Graphics Processing Unit". It is a processor designed to display three-dimensional graphics on a computer screen with a high frame rate, and is increasingly being used in Big Data analysis/Machine Learning.

A butterfly flutters its wings in 2005

The butterfly effect is a metaphor for the phenomenon of a seemingly inconsequential event - like a butterfly taking flight - triggering a serious event, such as a hurricane, on the other side of the world. The flutter starts a process that continues and amplifies. Intel has very likely been affected by just this type of effect, sparked by an event that occurred 15 years ago.

In May 2013, former Intel CEO Paul Otellini said that he was offered the opportunity to manufacture chips for iPhones in 2005, but the company declined, because they did not see the potential and underestimated how many iPhones would be produced, which turned out to be a hundred times the original projections. In hindsight, this could be classified as one of the biggest miscalculations in modern corporate history. If Intel had accepted the order from Apple and become the chip manufacturer for iPhones, "...the world would have been a lot different..." according to Otellini. Intel's decision in 2005 provided a golden opportunity for TSMC to manufacture more chips than Intel and thus go down the cost curve for transistor manufacturing more quickly. Today, TSMC has a two-year technological lead on Intel and dominates the production of chips for mobile devices. TSMC now manufactures three times as many chips as Intel and has therefore achieved lower unit production costs. This disadvantage of scale has most likely led to Intel's current difficulties with keeping pace with TSMC in the competition to continue to live by Moore's Law. In the future, it seems quite likely that Intel designed chips will be manufactured by TSMC or Samsung simply because Intel made a bad decision 15 years ago and missed out on the world's largest market for chips – smartphones and other mobile devices.

What are the consequences in the longer term?

The industry implications are that the growing market for the production of chips will be split between fewer manufacturers (TSMC and Samsung). The semiconductor market will accelerate over the next decade with an enormous market potential, driven by the Internet of Things, 5G, autonomous vehicles, Smart Cities and Industry 4.0 technologies.

"In the future, it seems quite likely that Intel designed chips will be manufactured by TSMC or Samsung simply because Intel made a bad decision 15 years ago and missed out on the world's largest market for chips.

The geopolitical implications are that Intel, in the longer term, stops manufacturing leading-edge semiconductors. However, viewed from a national security perspective, this will be completely unacceptable no matter who is in power in the US. Taiwan has become the world's largest manufacturer of semiconductors and will therefore, in the longer term, become the 'hottest hotspot' from a geopolitical perspective. The Americans are expected to demand that leading semiconductor manufacturers build production sites in the US. Ordinary competition considerations could even be suppressed, and the US could insist that the leading semiconductor manufacturers collaborate on American soil to expand the production capacity. It is in this light that TSMC's recent announcement about establishing a chip factory in Arizona should be viewed. Over the next decade, many more factories will be built in the US to guarantee American access to leading-edge semiconductors in an atmosphere of increasing geopolitical tensions with China.

Finally, Intel's challenges demonstrate how close we are to the maximum physical limits of Moore's Law. We believe that Moore's Law still has a decade to live (at least down to 3 nanometres). However, fewer and fewer companies have the capital, scale and technological know-how to remain relevant.