Data Analytics on Media Reports of Semiconductor Chip Shortage

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Abstract: The global chip shortage has been hitting many industries. This paper presents the results of a data analytics study of media reports of chip shortage. The analysis was mainly based on an examination of different publications from 2020 to 2021. This paper firstly introduces the concept of chip and its manufacturing process, then evaluates the nature, extent, and impact of the chip shortage, and finally reviews the historic chip shortage cases. This paper provides insights for researchers and practitioners, for example, improving processes and controlling inventory better to attenuate the chip shortage.

1 INTRODUCTION

A Chip, also known as a microchip, an integrated circuit or monolithic integrated circuit, is defined as "a circuit in which all or some of the circuit elements are inseparably associated and electrically interconnected" (JEDEC). Every final product of the chip goes through the process of designing, building and selling, which involves a great number of different corporate hands. Chips can be manufactured either by an in-house fab, or by an external foundry. For example, Intel as an independent device manufacturer (IDM), designs the chips by its engineers and manufactures the chips on its own fabs. Similarly, companies such as IBM and XilinX, they design and produce the chips using their own factories. But they also make chips for other companies. However, other companies such as Brand X are fabless chip companies, they use an independent foundry. Fabs and foundries need to purchase manufacturing tools and heavy equipment from a variety of tool suppliers located in America, Europe, and Asia. Some market leaders are Applied Materials, Tokyo Electron Limited (TEL), Nikon and KLA. Similarly, the necessary raw materials also need to be purchased from outside vendors, including silicon wafer, photomasks, gases, photoresists, other substrates, wet, ancillaries and deposition materials (N. Zlatanov, 2004). While large companies may have solutions to material shortages, small and medium enterprises (SMEs), such as SSL Corporation in Ningbo, suffers from significant chip shortage since it is dedicated to the production of automotive camera modules.

2 ANALYTICS ON MEDIA REPORTS

A Google search was performed to produce an overview of popularity of the chip shortage topic. The search result trend is presented in Fig. 1. We used a preliminary set of key words to search and download the full text related chip shortage from different publications such as the Dow Jones Newswires, the Reuters, the Wall Street Journal and other publications from 2020 to 2021. The results shown in Fig. 2 indicate that enterprises worldwide have been battling the semiconductor shortage since December 2020. In the past three decades, the global markets had witnessed the chips shortage constantly mainly due to the increasing demand or natural disasters. However, the sustained shortage are partially due to underinvestment due to the significant cost of opening a chip factory (Chou, 2007). For instance, in 2011, supplies of silicon wafers and other raw materials used for chip-making were disrupted due to the earthquake and subsequent tsunami in Japan

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(Brown, 2011). However, the pressure during 2020-2021 comes from both demand and supply sides, including surging demand, stagnant semiconductor capacity growth in past decade, shrinking semiconductor manufacturing labor market (Skanda, 2013) and higher supply chain vulnerability ("Semiconductor Contract Manufacturing Services Worldwide 1996", 2013); (Lee, 2021). Additionally, unlike historic chip shortage cases, multiple disruption events such as pandemic, trade war and natural disasters also add pressure and constrains on semiconductors production successively.

3 2021 CHIP SHORTAGE

The chip shortage during 2020-2021 was caused by multiple disruption including imbalance between increasing demand and stagnant supply, shrinking labor market, high supply chain vulnerability, trade war and natural disasters. The combination of the disruptions added much more pressure and constraints on chip production and have more global impacts, while past chip shortages were mainly caused by single event thus impacted less regions and industries.

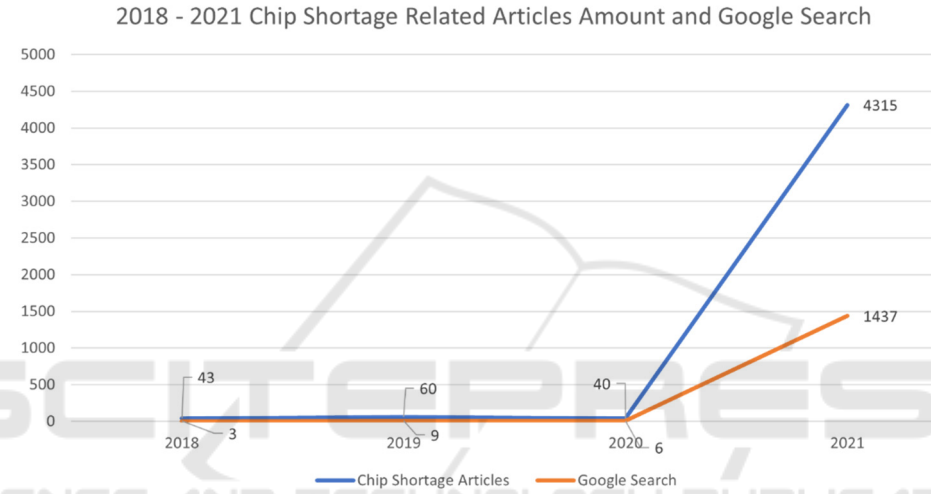

Figure 1: Google Search Results About Chip Shortage, 2018-2021.

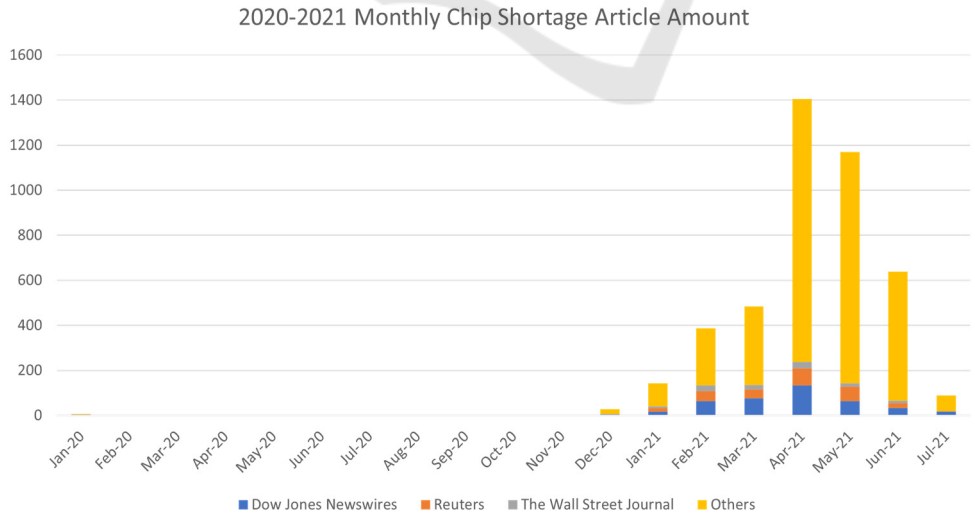

Figure 2: Number of Chip Shortage Reports by Month, 2020-2021.

The steady rise of chip demand slightly declined in 2019. At the start of 2020, the rollout of 5G was expected to create a surge in demand for chips in mobile industry. There were also predictions of increasing demand of chips in automotive and industrial applications. Unexpectedly, due to Covid-19 pandemic, there was a surge in demand for laptops and servers for staff working remotely and children home-schooled. Data from Bureau of Economic Analysis illustrated that in 2020 the spending of computer and peripheral equipment increased by 30 percent from $120 billions to nearly $160 billion (Printed Electronics Now, 2021). The revenue of semiconductor industry increased by 10.8 percent to $464 billions from 2019 to 2020, demonstrated by IDC data (Issue Alert, 1986).

Geopolitical factor also played a role when Huawei Technologies, ZTE, and other Chinese firms have been sanctioned by the Trump administration. Those companies started to stock up chips for 5G smartphones and other related electronic devices. Also, American enterprise cannot access to the chips made by China's Semiconductor Manufacturing International Corporation after the federal government listed the firm on the entity list.

The lead time for many semiconductors is more than one year in 2021, compared with 14 weeks in 2018 (K. Ian, 2021). The lead time were expected to continuously widen. Some key reasons are that the semiconductor industry are highly underinvestment and underemployment.

To respond to the increasing demand of chips, the semiconductor industry is continuous increasing fab capital investment. Some semiconductor manufacturers had increased capital budget on building new fabs. For instance, Taiwan Semiconductor Manufacturing Company (TSMC) increased its capital spending budget to $26 billion. South Korean, with Samsung as one of the leading semiconductor enterprises, has announced significant investment, $451 billions investment package in semiconductor development (G. Matthew, 2021). However, experts believe that it would take more than 5 years to fund and build a new semiconductor fab, which cannot immediately ease the shortage (K. Ian, 2021).

Along with persistent underinvestment in semiconductor industry, it would be no surprise that the labor market trend of semiconductor industry would be consistent with the investment trend. Data from the Bureau of Labor Statistics has shown that the employment was peaked in 2000 along with the tech boom and never recovered after the recession in 2001 (Skanda, 2013). In 2020, the number of employees in semiconductors and related devices manufacturing is only half of it in 2000.

Apart from underinvestment and underemployment, there are some other disruptions leading to the chip supply chain disruption. For instance, in July in 2020, a fire at Japanese factory led to a cut off of fiberglass used for printed circuit board (Chelsey, 2020). In late October in 2020, a fire at Asahi Kasei Microdevices (AKM) semiconductor factory led to supply chain interruption for some end-products (TTI, 2021).

With panic, lockdowns, and general uncertainty rolling across the globe under the Covid-19 pandemic, the shipping of the parts for chip-making has been disrupted. Especially, infections at some key points in the semiconductor supply chain in Taiwan would worse globally chip shortage. Outbreaks at some key ports lead to global shipping delays of semiconductor parts (Xie, 2021).

Semiconductor manufacturing capacity shifted from evenly-distributed-worldwide to Taiwan-dominated, leading to higher supply chain vulnerability. There are three or four semiconductor foundries accounting for the global chip supply with TSMC and Samsung dominating the business. The estimated revenue of TSMC was $12.9 billion for the first quarter of 2021 (Yang, 2021).

4 HISTORIC CHIP SHORTAGE CASES

Historic chip shortages are caused by single reasons instead of the combination of economic, political and social reasons, which is different from 2021 chip shortage. We list these shortages in reverse chronological order.

In 2012, with booming smartphone market, there was an increasing demand of chips. Qualcomm, one of the largest chip makers, underestimated its demand of Snapdragon S4 chips. Qualcomm's manufactures cannot secure enough supply to meet the orders of this chip, which lead to chip shortage (Clark, 2012).

In 2011, semiconductor enterprises have experienced supply disruption, which is caused by Fukushima earthquake and subsequent tsunami. On the demand side, there was an increased demand in automotive industry while sluggish demand of chip used in PC. In terms of the supply, Fukushima earthquake and tsunami disrupted the supply of silicon wafers and other raw materials used for chip-making, leading to the 2011 chip shortage (Matsuo, 2015).

Back in 2004, there is a CDMA shortage from the mobile phone industry and card chip shortage from the bank industry with card technology updated. In terms of the mobile industry, during the first half of 2004, the demand by mobile network operators has continued unbated, especially with the introduction of 3G network service and more storage space needed for data storage. Also, Chinese operators continued to stock up chips to avoid unexpected tighten supply of chips. In terms of the bank industry, bank converted magnetic stripe payment cards to more smarter and secure cards (Clark, 2004).

In terms of supply of chip, Qualcomm has controlled about 88 percent of the CDMA chipset market, but experienced supply constraints and resulted in unable to meet certain orders. The CDMA chip market as a whole experienced a tightens supply. Qualcomm's supply constraints may give rival CDMA chip suppliers a chance to compete in the market (Clark, 2004).

In 2000, the explosion of cellular phones, technically sophisticated toys and personal computers has caused unprecedented demand for semiconductors. The capacity of chipmakers such as Intel Corp., Advanced Micro Devices, and Fujitsu Ltd cannot meet the explosion demand of chips. Chip lead time doubled from 30 to 40 days to 60 to 90 days. The chip shortage has forced toy manufacturers delaying introduction of some interactive toys until the following year. For instance, Sony has to cut in half the number of PlayStation 2 game console. In computer industry, the computer chip shortage was driven by corporate demand for personal computers. AMD holds an estimated 17 percent market share with 82 percent for Intel. The increased demand of microprocessor, booming server sales as companies built and expanded website worsen the chip shortage (“Semiconductor Contract Manufacturing Services Worldwide 1996”, 2013).

In 1988, the chip shortage was caused by high demand of the personal computer market and tightening supply due to US-Japan semiconductor trade agreement. The agreement demonstrated Japan agreed to limits its exports of semiconductors, mainly the "dynamic random access memory" (DRAM) chips, to the U.S. Back in 1985, the U.S manufacturers has imported record number of chips from Japan to meet their needs for personal computers. Japanese firms accounted for 92 percent of the sales of the whole chip sales in the U.S. market (Flamm, 2007).

5 CONCLUSION

This paper presents the results of a data-driven investigation of media reports regarding chip shortage. Historic chip shortages are caused by single reasons instead of the combination of economic, political and social reasons, which is different from 2021 chip shortage. From our analysis on media reports, yield problems and other forms of uncertainties could also lead to more incidents of chip shortage, and appropriate supply chain design could alleviate these uncertainties (Cai, 2017; Li, 2021; Ji, 2020). Process improvement and better inventory control may potentially attenuate the chip shortage problem. (Li, 2018; Li, 2019)

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