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Price Equilibrium and the Global Semiconductor Shortage

ECONOMICS (030)

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Aashima Khanna

XI-K

Certificate

I, Aashima Khanna, student of class XI-K of Delhi Public School R.K.Puram hereby certify that the project was undertaken by me as a part of the CBSE curriculum. The data used in the project has been collected by me from multiple sources mentioned in the bibliography and therefore I consider it to be authentic and reliable.

Aashima Khanna

Introduction

In the last couple of years, the Covid-19 pandemic has impacted all industries including that of electronic products, vehicles, smartphones and other gadgets. These industries have seen major losses, with car companies getting shut, electronics being delayed and cloud seeing failures. All can be attributed to the shortage of semiconductors or “chips”.

Problem Statement

Chip shortage has led to the price of semiconductors and other electronic components rising by 8% between 2021-2022. This price has been on a constant average annual decline of 2.5% since 1994 (for 17 years). This shortage has had impacts on both supply and demand as consumers have moved away from spending on services, the world has seen global supply chain disruptions and huge boom in the tech industry. With both supply and demand impact, equilibrium prices for chips and hence the final products has been impacted by various factors.

As the media reports on inflation, the questions arise – why is there a shortage? What is the impact on consumer economy? And more importantly, what are its long-term implications?

Importance of the problem

Semiconductors, sometimes referred to as integrated circuits (ICs) or microchips, are made from pure elements like silicon or germanium or compounds such as gallium arsenide. These chips are an important part of our lives as they are not only used in smartphones, computers, and vehicles but also in advanced medical and diagnostic equipment.

While chips are only 0.2% of global output, they are an important input to ~12% of global economy. Thus the shortage has had an impact on the ability to meet the rising demand for these products.

Economists like Rory Green at TS Lombard wrote, “As the world becomes more interconnected, more automated and greener, each unit of GDP growth will contain a higher content of semiconductors. Integrated circuits are becoming the key commodity input for economic activity.” He calls chips the “new oil” as he adds “The current severe shortage of semiconductors, which is halting automotive production worldwide, underscores the speed and scale of the changes under way.”

While this inflation is not expected to last beyond 2022, according to economist Spencer Hill at Goldman Sachs it “represents another reason to expect core goods inflation to remain firm this year.”

Deeper dive into the Shortage

As we try to understand the shortage better in this report, we will look at the causes and consequences at different stages of the pandemic starting March'2020. These stages are based on:

- The industries that started to thrive
- The industries that started to fall
- Economic restart
- Manufacturing bottlenecks
- Consumer willingness to spend

Criteria for stages of the pandemic

Initially thriving industries and their impact on chip demand

As the pandemic impacted billions of people, creating a cleanliness frenzy and opportunities of working from home, demand for some goods and services picked up exponentially. However, only few of these had dependencies on chips, or use chip as inputs.

The tech industry uses chips to build servers, thus impacting the demand for chips. Industries like cleaning services, grocery stores, liquor stores, tutoring services, used cars markets and telehealth providers are highly dependent on the cloud for functioning. As people started fearing leaving homes and becoming highly germ conscious, these industries started to thrive, which in-turn led to an increase in cloud demand.

The cloud also services online conferencing, remote work and online gaming. These are industries that soared during the pandemic as people had more time to spare and offices shut down. Computers, smartphones and gaming devices also saw an increase in demand due to the same.

The impact on input's demand due to output's demand is similar to the impact of complimentary goods. Thus, with increase in cloud demand, the chip demand would see an increase of the rightward movement. This increase would increase the equilibrium price of the chips if supply were assumed unchanged.

Draw graph 1

Initially falling industries and their impact on chip demand

Starting of the pandemic transportation, hotel and retail industries took major hits. As these are not highly dependent on chips as an input, the chip demand was not affected as much. If they were dependent, the demand would've seen a decline (or leftward movement).

Economic restart

As the economy started to pick up, the demand for durable goods started to spike. Goods such as cars and home appliances which are now digitized highly rely on chips. However, even before the pandemic

had started the semiconductor manufacturing facilities known as fabs were already operating at nearly full capacity lacking ability to expand production. Start of the pandemic with shift to cloud, these companies had started focusing on producing modern “bleeding edge” chips and thus with the spike in commoditized chips used in automobiles and appliances, they created a shortage.

These bleeding edge chips can be considered substitute products to the commoditized chips thus, reducing the supply for output from automobile and appliance industries.

Draw graph 2

Manufacturing Bottlenecks

Fabs are highly concentrated in Southeast Asia. 87% of the fabs are in Taiwan with 54% of the global demand supported by Taiwan Semiconductor Manufacturing Co. 18% of the demand is supported by South Korea, 6% by China and remaining 13% is all over the world. This concentration of supply led to inevitable supply chain disruptions, again causing artificially reduced supply for companies all across the globe and transportation industries slowing down.

Consumer willingness to spend

2020 saw a tangible shift in the amount and nature of consumer spending due to the fear of Covid-19, social distancing measures and outright closures. Personal consumption expenditure fell in 2020 as options for spending declined. The personal savings rate at the end of 2020 was 14.2% nearly double that of the previous year. This spending did not rise until March of 2021 when it reached Feb2020 pre-pandemic levels.

After a dip in all expenditure In April2020, another shift happened as expenditure on durable goods increased. The PCE for durable goods, when compared to that in Feb2020, was 30% higher while it was 7% lower for services in April 2021.

In 2021, consumers started to spend more on services again and vacations resurfaced with the airline industry picking up and creating more demand for commoditized chips. This did not, however, create a decline in the cloud, computing, or gaming industries.

Impact on Chip equilibrium during different stages of the pandemic

Based on the above criteria, the pandemic can be divided into 3 different stages. Each with its own challenges and equilibrium impacting factors, creating a fascinating economic balance and implication. The stages we will focus on are:

1. Early Pandemic: Rise in remote work
2. Mid Pandemic: Economic restart for durable goods
3. Late Pandemic: Economic restart as a whole

Early Pandemic: Rise in remote life

This stage can be characterized as the 180-degree shift. Some countries seeing complete lockdowns, offices shutting down, work from home culture increasing for all non-essential workers. Only essential workplaces like grocery stores, hospitals, clinics and gas stations stayed open for service.

People had to adapt to their children no longer physically going to school or not getting any childcare services along with cooking all meals and working from home. In this interconnected world, technology then came to the rescue. People started working on their computers from home, buying more monitors and keyboards, while students started learning from home again requiring home electronics. Socializing, including birthdays, became zoom calls. Companies like Zoom and Microsoft (with teams) saw spikes in demand, supporting millions, and their stocks peaking 2-9X.

This led to an increase in tech demand, delayed supply due to supply chain disruptions and closed factories with workers getting highly affected.

Draw graph 4

With this increase in price of chips, companies like HP had to hike up their computer prices by 8% while Microsoft cloud due to surge in teams usage surpassed its biggest cloud competitor AWS in quarterly revenue. The companies still could not prevent customer failures since lead times for semiconductors rose to new highs.

Mid Pandemic: Economic restart for durable goods

This stage can be characterized as the “décor” era. This is the time when families were not going on vacation but had a habit of saving for vacation so started decorating their homes, updating their appliances and vehicles. However, due the lack of diversification in fabs’ geographies, no expansion possibilities and shift into modern chips, chips supply severely impacted automobile companies. Especially companies like Ford and General Motors that had to shut down plants temporarily expecting earning cuts of $2 Billion each.

Draw graph 5

Late Pandemic: Economic restart as a whole

This stage can be characterized as the "maybe an endemic" time. This is when people started to open to traveling again, and using public transportation, and going to restaurants to eat. Most cities opened completely with only restrictions on extremely large gatherings. This is when the world had almost started looking like normal. However, even during this time cloud demand was spiking, durable good demand had not gone down, and the automobile supply was starting to pick up. With this hit, another strain of virus, Omicron and companies/school went back to remote life. Thus, servers and cloud demand is still rising.

Companies like Taiwan Semiconductor Manufacturing Co. are set to maintain the price hike in 2022 while renewing contracts since the supply or manufacturing capacity still can't meet the demand easily.

So, while this stage is not expected to see any major rightward shifts in demand, it is expected to see a price floor which could be above the equilibrium price thus creating an increase in the price for the same demand quantity.

Draw graph 7

Final Pricing

Based on the current demand predictions for cloud, services and other durable goods, the demand is not expected to rise beyond average growth rate. However, with the semiconductor manufacturing companies applying price floors to ensure sufficient supply and improved profits, the shortage could continue. With the world going back to traveling, a shift in the type of chip is also expected and could create a shortage for the tech industry.

Remedies

Since this price equilibrium issue is caused by two major factors:

- Pandemic creating increase in remote work;
- Supply not being able to keep up with the demand increase

The remedies revolve around those.

While the solution to the pandemic is ongoing and remote work here to stay for a while, the question arises- why not just produce more chips?

The simple answer is that making chips is incredibly difficult even stemming an inside joke "It's not rocket science, it's much more difficult". The more complicated answer is that it takes years to build the fabrication factories along with billions of dollars. The production and economics so complex that even if your manufacturing expertise is a pin tip behind the competitors, the results could be catastrophic.

Chip plants run 24 hours a day for seven days a week to optimize cost. The investment for an entry-level factory that produces 50,000 wafers per month is about $15 Billion. Most of this is on specialized equipment for a niche audience. Manufacturing a chip takes more than 3 months and involves giant

factories, dust-free rooms, multi-million-dollars machines, molten tin, and lasers. The end goal being converting silicon wafers into a network of billions of tiny switched called transistors.

Stakeholders affected

This shortage driving the price equilibrium has impacted 169 industries with each having different impact on stakeholders- Consumers, Input manufacturers and output manufacturers. Consumer seeing higher prices for goods while not being able to purchase all that they want, input manufacturers running at their bottleneck capacities and output manufacturers seeing losses and creating revenue restatements.

Consumers

As mentioned before, consumers not only saw increased prices of cars and appliances but also of consumer electronics and Led lights. Companies like HP increased their printers prices by 20% on average in a single year. Bloomberg reported that Sony wont meet customer demand for its new gaming console PlayStation 5 until late 2022. The big sales like Labor Day Appliance sales didn't have supplies last.

Output Manufacturers

Output manufacturers are the industries that create the final products and use chips as inputs to their production. The most hit industry was the auto industry. Even the most basic new cars rely on specialized microchips to function. In fact, even the key fobs that so many vehicles need to operate can't work without chips. By the end of July, at least 17 factories in Europe and North America had either stopped or slowed production for lack of computer chips, according to the Washington Post.

Some of the biggest names in the industry — including Tesla, BMW, General Motors, and Ford — have been hurt by the shortage. When all is said and done, the global auto industry will crank out 4 million fewer vehicles this year than planned and forfeit $110 billion in sales.

At the start of the mid-pandemic era, LED Inside reported that companies like Apple and Samsung were preparing to debut their latest laptops, tablets, and TVs. They all had one thing in common — they were all equipped with mini-LED backlights powered by chips that were increasingly hard to find.

Input Manufacturers

This is primarily the companies that manufacture chips. They were seeing so much shortage that prioritization of demand and customer management was their biggest hurdle along with manufacturing at peak capacity. While expansion is a long-term task, in the short term, companies predicted demand to outpace supply for at least a couple more years. The current lead times for chips are also 15 months – 2 years. This is, again, as shared previously an equilibrium impacting act from manufacturers.

Advantages and Disadvantages of issues identified

While the biggest disadvantage of the chip shortage is lack of ability to meet consumer demand and industrial losses, the shortage actually signifies long term growth.

The world is digitizing, with most products requiring chips, thus any increase in demand will only lead to an improved economy in the future.

The shortage has caused some deep conversations around the supply chain, environmentally friendly alternatives, and price management.

Strengthening supply chains today

A research paper from Accenture beautifully highlighted the long-term supply chain changes that need to be made to maintain prices and ensure sufficient supply for growth.

Looking at long-term preparations, companies can build supply chain resilience into their planning and manufacturing processes by evaluating these key considerations:

- Know your supply competitors
- Rethinking supply networks and co-location
- Time's up for just-in-time

Know your supply competitors

Companies typically forecast for their customers based solely on their customers' needs; that means a smartphone manufacturer will forecast for the chips they need based on demand for their smartphones. While that does make sense, the recent shortage has clearly highlighted the need for companies to look across the entire ecosystem and consider which other sectors they might have to compete with—both from a demand and supply perspective.

Rethinking supply networks and co-location

As we've witnessed with the pandemic of 2020—and the abrupt halt to overseas transit—dependencies on overseas vendors for critical supplies are a vulnerability. Companies should give serious consideration to not only multi-sourcing strategies but also to a hybrid of insourcing and outsourcing. While building or procuring domestic fabrication houses is costly, investing in on-premises manufacturing can add supply assurance and increase leverage over supply during times of spiking demand. This type of co-location strategy would shrink the length of trade routes and move end points closer on the supply chain network.

Time's up for just-in-time

Supply chains were built on the just-in-time efficiency principle for many components, including semiconductors: optimizing metrics under the assumption that things will always run in sync. However, this recent situation has clearly demonstrated that, when faced with semiconductor supply chain disruptions, working under this principle can have a devastating impact. When the shortage of a 10-cent chip can potentially halt the entire production line of a $30,000 car, and with demand for semiconductors ever increasing, it isn't difficult to see why the threat of chip shortages far outweighs the benefits achieved by just-in-time supply chains.

Circular Economy: Shifting from Disposal to Recycle

According to an article in AZO Materials, it has been estimated that 1 million smartphones contain the equivalent of 15 kg palladium, 34 kg gold, 350 kg silver, and 16,000 kg copper, while under normal circumstances ca. 3%–4% of the daily 250,000 silicon wafers placed into manufacturing are scrapped.

These chips can be recycled to produce more advanced chips. Minimizing new resources while maximizing value from materials needs to be the new norm. For companies to really act on their greener initiatives, reclamation would need to be more cost effective, less toxic and wasteful. Gallium arsenide and expensive rare earth element (REE) materials extensively used in semiconductor production require an escalation in their recovery from processing.

In 2020, 4 million kg of materials was reused to meet the chip demand to create refurbished less sophisticated chips for industries like appliances and LED lights.

Case Study: Sony PlayStation5 shortage impacts gamers and developers

PS5 shortages and supply chain bottlenecks

There are myriad factors behind the current semiconductor chip shortage including COVID-19-related closures, global politics, and more. In the 21st century, semiconductor chips are critical to a vast spectrum of industries and consumer products ranging from smartphones to smart cars. This means console manufacturers are now vying with new industries for chip production space.

"The massive demand for PS5s combined with the chip shortage may have hit Sony particularly hard as Japanese companies tend to follow just-in-time manufacturing standards that dissuade gathering stocks of components prior to the need for them, making them more susceptible to supply chain disruptions," Gittins said.

How long will the shortage last?

To score a new console, many avid gamers have little option other than to scour online retailers and refresh websites throughout the day as new shipments become available. So how long could the chips shortage and limited PS5 continue?

Gittins said the semiconductor shortage isn't likely to be "fully relieved" until next year, although she said the situation should "improve throughout 2021." Although it is possible these shortages could continue into the winter holiday shopping season.

"The PS5 demand will remain high for quite some time as Sony seems keen to move at least 15 million units, so I suspect we will see challenges with distribution until after the holiday sales boom of this year," Gittins said.

Puneet Saxena, global vice president of Global Manufacturing Sector at Blue Yonder, offered a comparatively more optimistic forecast and said the situation may take between three to four months to be resolved. Either of these estimates won't help logistics and deliveries in the next few months.

"There is short-term frustration for gamers on the road ahead," Saxena said.

Impact on gaming developers and studios

Whether the shortages will exist as a short-term challenge or a lingering logistical constraint remains unclear. However, the current dearth of semiconductor chips and the diminished supply of PS5 consoles could affect developers and studios in this space.

"The profit margins of the average game are quite small or even negative. While we see many blockbuster hits, the average studio is constantly struggling to make ends meet, so this disruption may very well cause studios to go under that would have succeeded," Gittins said.

The shortages and limited console availability are causing game developers to miss out on marketing and sales opportunities, Gittins said, although many developers are releasing projects on previous console generations. For the time being, gamers are the ones most impacted by the supply shortages, she said.

"With both the PS5 and current generation graphics cards in short supply, avid gamers will find themselves struggling to acquire a platform to enjoy the high quality graphics and gameplay of the newest game releases," Gittins said.

This shortage also led to increased prices for the consoles in the resale market. Again impacting price and going almost as high as twice the MSRP.

Draw graph 6

AI forecasting and future supply chains

Necessity breeds inventions, as the adage goes. So, how will the lessons learned during this supply shortage impact the way organizations forecast supply and production in the future? In the age of accelerated digital transformation, some companies could look to take automated tools to streamline workflows.

A "revised approach" to consumer electronics supply chain management focused on resilience has "become the central topic of discussion across the entire electronics value chain," according to Saxena. Rather than predicting consumer demand with traditional methods, Saxena said some manufacturers are examining the use of artificial intelligence to "sense changes in demand patterns much faster."

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