Automotive microchip e il “chip shortage”

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Effect on industries

- Many industries worldwide, from automotive to healthcare, are affected by the chip shortages. Some forecasts estimate that **automakers will produce between 6.3 and 7.1 million fewer units in 2021** due to chip supply constraints
- *Mark Fulthrope and Phil Amsrud. 2021. "Gobal light vehicle production impacts now expected well into 2022". https://ihsmarkit.com/research-analysis/global-light-vehicle-production-impacts-now-expected-well-into*
- As almost every industry is dependent on semiconductors to some extent, Goldman Sachs estimates that around 169 industries globally are impacted by these chip shortages

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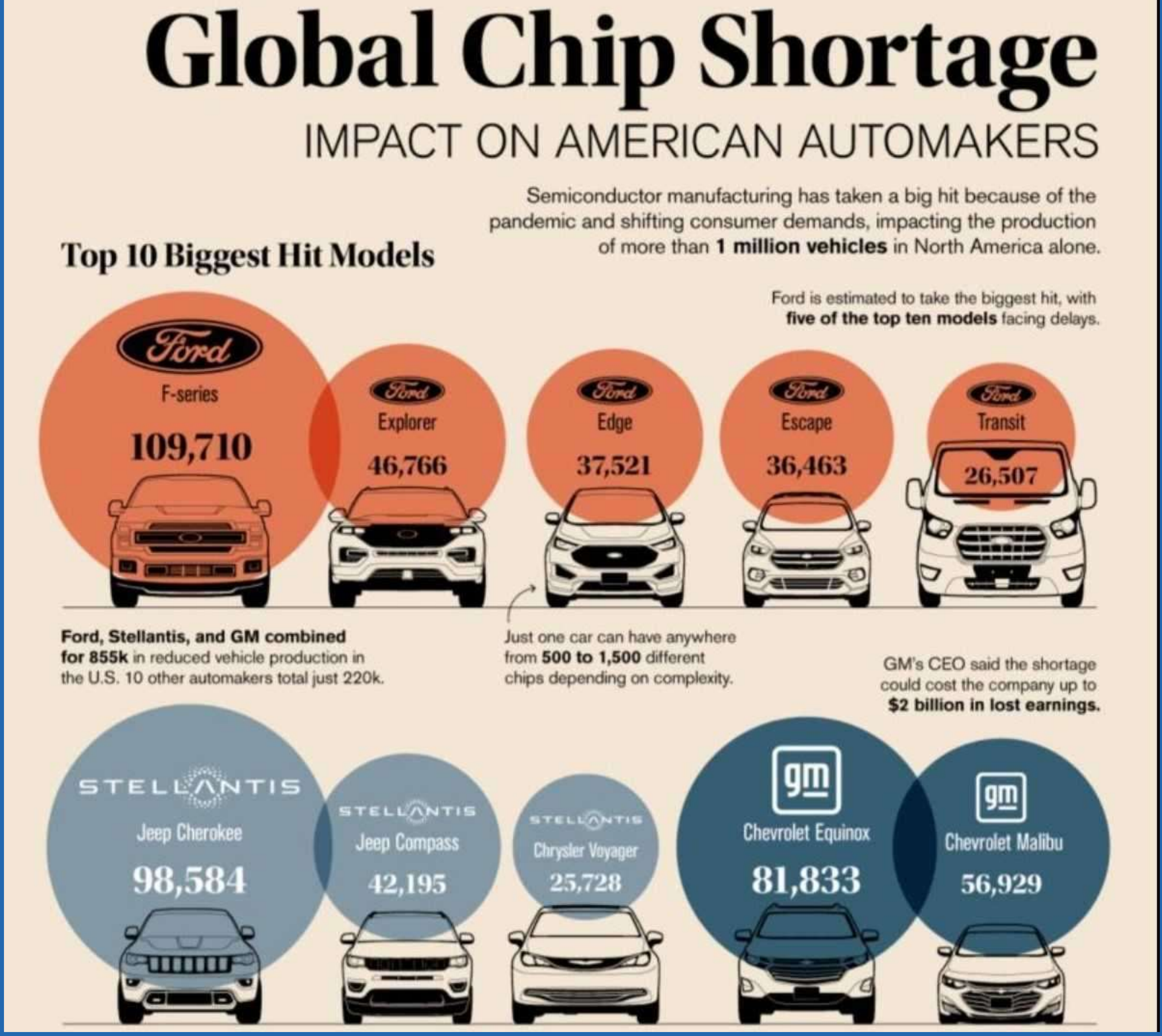
Global Chip Shortage
IMPACT ON AMERICAN AUTOMAKERS
Semiconductor manufacturing has taken a big hit because of the pandemic and shifting consumer demands, impacting the production of more than 1 million vehicles in North America alone.
Top 10 Biggest Hit Models
Ford is estimated to take the biggest hit, with five of the top ten models facing delays.
Ford
F-series
109,710
Ford
Explorer
46,766
Ford
Edge
37,521
Ford
Escape
36,463
Ford
Transit
26,507
Ford, Stellantis, and GM combined for 855k in reduced vehicle production in the U.S. 10 other automakers total just 220k.
Just one car can have anywhere from 500 to 1,500 different chips depending on complexity.
GM's CEO said the shortage could cost the company up to $2 billion in lost earnings.
STELLANTIS
Jeep Cherokee
98,584
STELLANTIS
Jeep Compass
42,195
STELLANTIS
Chrysler Voyager
25,728
gm
Chevrolet Equinox
81,833
gm
Chevrolet Malibu
56,929

Automotive chip shortage: why?

1) Automakers decided to cancel chip orders during H12020 because of pessimistic demand prospects due to COVID-19.
   This "freed up" wafer capacity at foundries was quickly filled with orders from consumer electronics; demand in this sector skyrocketed
2) When automotive demand increased sooner than expected, car manufacturers quickly ran out of chips because of their just-in-time supply chain model, which generally tries to avoid inventories
3) 3 dynamics kept carmakers from quickly receiving the necessary chips:
   - high fab utilization
   - long manufacturing cycle times
   - limited sources

High fab utilization: Foundries were almost fully booked in 4Q2020 when automotive suppliers ran out of chips. The existing wafer capacity was completely utilized by other customers, and there was no overcapacity available to accommodate carmakers

With a global market share of less than 12%, automotive semiconductors play a smaller role in the market compared to consumer electronics or TLC

Automotive chip shortage: why?

Long manufacturing cycle times: When the supply is stable, it takes **four to six months** to manufacture a chip. These long production times are incompatible with a highly complex just-in-time automotive supply chain.

Limited sources: Automotive chips have stringent safety requirements (weather resistance, fault tolerance, redundancy, etc.) that must be certified, including the production process.

This limits the number of fabs that automotive chip suppliers can rely on, putting further stress on an already strained supply chain during times of scarcity

What disrupted the global chip value chain?

Consumer electronics, such as laptops, smartphones and tablets, and PCs for home or office use make up the lion's share of global semiconductor demand.

The most important factor that disrupted the global semiconductor value chain was the **skyrocketing demand for chips due to**

- **COVID-19**
- **US-China technology rivalry**

Global semiconductor sales were

18% higher in 1Q21 than in 1Q20,

29% higher in 2Q21 than in 2Q20

28% higher in 3Q21 than in 3Q20

forecasts predict **that >20% more semiconductors will be sold in 2021 vs 2020**

Role of Covid-19 and US-China rivalry

Since 2020, working from home and home schooling were the new normal in many countries. As many companies lacked the necessary equipment and infrastructure to enable work from home, many PCs and laptops were bought. With remote work and video calls data center and server equipments were in high demand. Staying at home due to curfews and lock-downs meant that many people invested in gaming consoles, home PC and other gadgets.

Lock-downs forced fabs to shut down temporarily.

When the US placed export bans on Huawei in 2019, Chinese companies started hoarding chips out of fear of facing similar challenges if being put on the US entity List. Thus, it is understandable that Chinese companies started stockpiling chips, but by doing so they contributed to skyrocketing demand.

External factors brought further disruptions to a strained supply chain

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Year	Country / City	Incident	Process step	Affect. Corp.
2020	Japan (Sakurashimo)	fire[69,70]	Chemicals	Nittobo (ABF)
2020	Taiwan (Taoyuan City)	fire[71]	Chemicals	Unimicron
2020	Japan (Nobeoka City)	fire (3 days)[72,73]	Fab	AKM
2020	Taiwan	one hour power outage[74,75]	Fab	Micron
2021	Taiwan	second fire[76]	Chemicals	Unimicron
2021	Japan (Tokyo, Fukushima, Shirakawa)	earthquake & power outage[77]	Fab, Chemicals	Renesas; Shin-Etsu
2021	US / Texas	winter storm, power failure[78,79]	Fab	Samsung, NXP, Infineon
2021	Japan (Hitachinaka)	fire[80,81]	Fab	Renesas Naka factory
2021	Taiwan	drought, freshwater reservoir shortage[82,83]	Fab	TSMC, UMC
2021	Taiwan	temporary power outage at Tainan Science Park plant (7 hours)[84,85]	Fab	TSMC
2021	Malayisa	lockdown measures[86,87]	Back-end Fab	Infineon Technologies, NXP Semiconductors, STMicroelectronics, Intel, Texas Instruments, ASE, Amkor, TFME, Hua Tian, etc.
2021	Taiwan	lockdown measures[88]	Back-end Fab	King Yuan Electronics Co

Six characteristics of the chip industry

Six characteristics define the inner working of the semiconductor manufacturing industry:

1) high division of labor
2) high capital intensity
3) high knowledge intensity
4) long manufacturing cycle times
5) transnationality
6) strong lock-in effects

High division of labor

The semiconductor industry’s high levels of innovation and efficiency are rooted in a highly specialized and interdependent ecosystem.
A high division of labor is distinctive across not only the main process steps but also in the supplier markets.

Modern chip production involves thousands of highly specialized companies.

The high division of labor is a result of the economic pressure to constantly innovate

High capital intensity

Semiconductor manufacturing is highly capital intensive.
Building a modern fab (5nm) requires USD 20 billion in capital expenditure, and a single cutting-edge lithography machine from ASML costs USD 175 million.
Large fabs need around 20 of them.
These extremely high capital expenditures for cutting-edge manufacturing are one reason the market has been heavily consolidated over the past 20 years.

The only three companies that still operate cutting-edge fabs (TSMC, Samsung and Intel) accounted for more than 50% (USD 59.4 billion) of global semiconductor capital spending in 2020

High knowledge intensity

Semiconductor companies have high R&D expenditures.
In 2020, the semiconductor industry spent > 14% of revenues on R&D.
Chip design (fabless) companies that out-source manufacturing, such as Nvidia, AMD and MediaTek, invest 20–25% of their revenue in R&D.

However, semiconductor manufacturing also relies on extensive process knowledge based on decades of experience and skilled workers.
To develop future manufacturing processes, foundries and integrated device manufacturers (IDMs) have R&D collaborations with research and technology organizations (RTOs) and equipment suppliers.

Historically, U.S. companies and institutions have the highest share of global semiconductor R&D, but South Korean, Taiwanese and Chinese companies have become important R&D partners in recent years

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Long manufacturing cycle times

Producing a single chip requires up to 1500 steps, each based on hundreds of variables.
Some process steps during wafer fabrication, such as oxidation and coating, lithography, etching and doping, are repeated hundreds of times, depending on the specific chip.
Thus, wafer fabrication from start to finish (cycle time) takes, on average, 12 weeks but can take up to 20 weeks.
Then, the wafers are delivered to back-end manufacturers (assembly, test, packaging)
In total, producing a semiconductor can take more than 6 months.
Consequently, the industry is characterized by long-term planning with customers placing their orders well in advance.

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Transnationality

USA, Japan, South Korea, Taiwan, the EU, China and Southeast Asian countries play critical roles within the semiconductor value chain. No region is able to source all necessary inputs and perform every process step domestically

Strong Lock-in effect

This transnational value chain, having close connections is essential for competitive products. This, in turn, creates strong lock-in effects between companies, making it harder
to switch suppliers or manufacturers. One example is the close business relationships between chip design companies and foundries for contract manufacturing. It’s a strategic decision as chip design companies cannot simply switch nodes once the chip has been developed.

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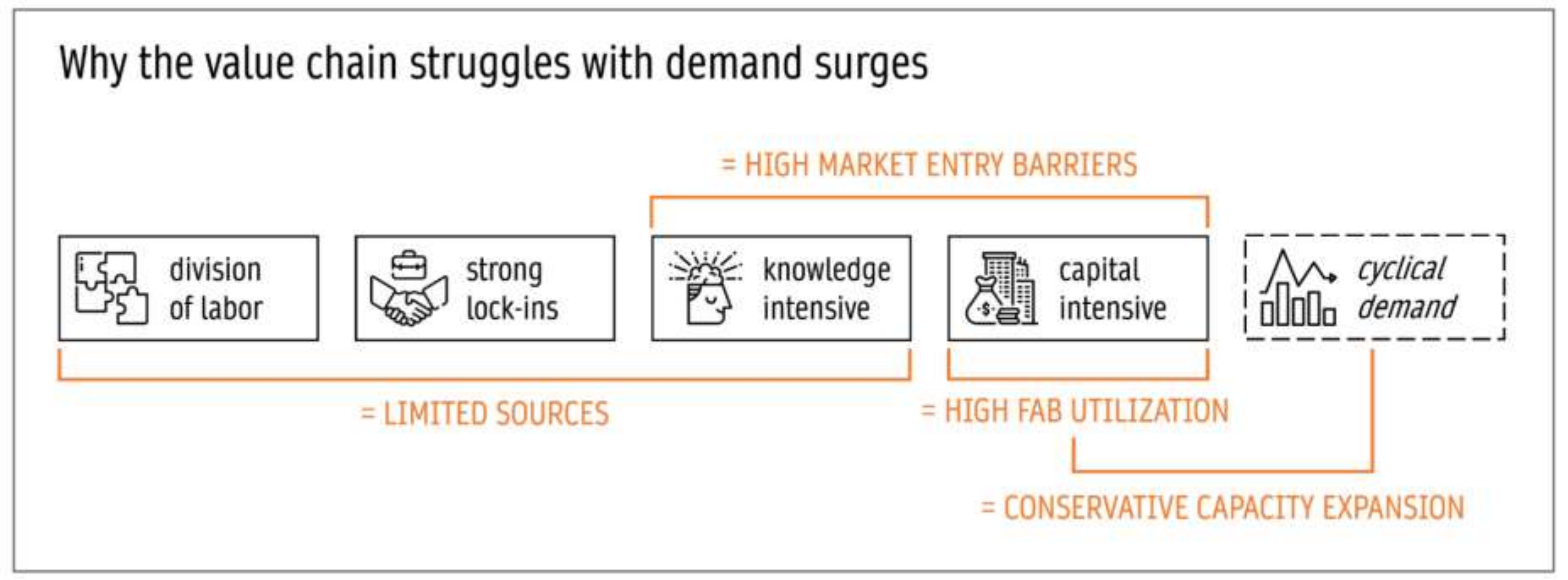
Chip manufacturing chain fragility

Increases in demand threw the semiconductor value chain off balance because of high market entry barriers, high fab utilization and limited sources



Chip manufacturing chain fragility

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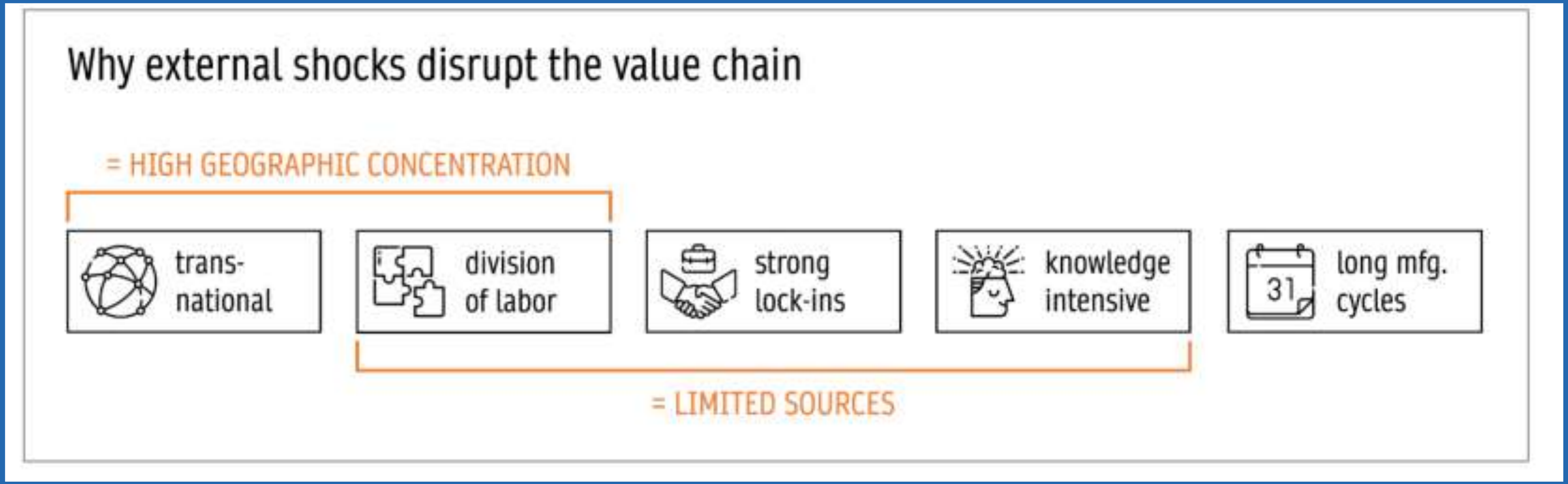
- The high market entry barriers of semiconductor manufacturing mean that even in the mid-term, the value chain can rely only on existing companies
- Operating close to full capacity is the only way to amortize the high investment costs. This, in turn, means that the market has very limited “spare” fabrication capacity, and fabs are quickly booked out if there is a fast increase in demand
- In 3Q20, when shortages started to materialize, the average fab utilization rate was already at 95%
- TSMC’s CEO said in spring 2021 that their fabs had been “running at over 100% utilization over the past 12 months

Chip manufacturing chain fragility



- **Another contributing factor to chain fragility is the reliance on limited sources. There is no abundance of suppliers for a particular process step, type of equipment because of the industry's high knowledge intensity, high division of labor and strong lock-in**
- **Quasi-monopolies are very common throughout the value chain because companies have to specialize to stay competitive**
- **The global semiconductor value chain is susceptible to external shocks also because of high geographic concentration**

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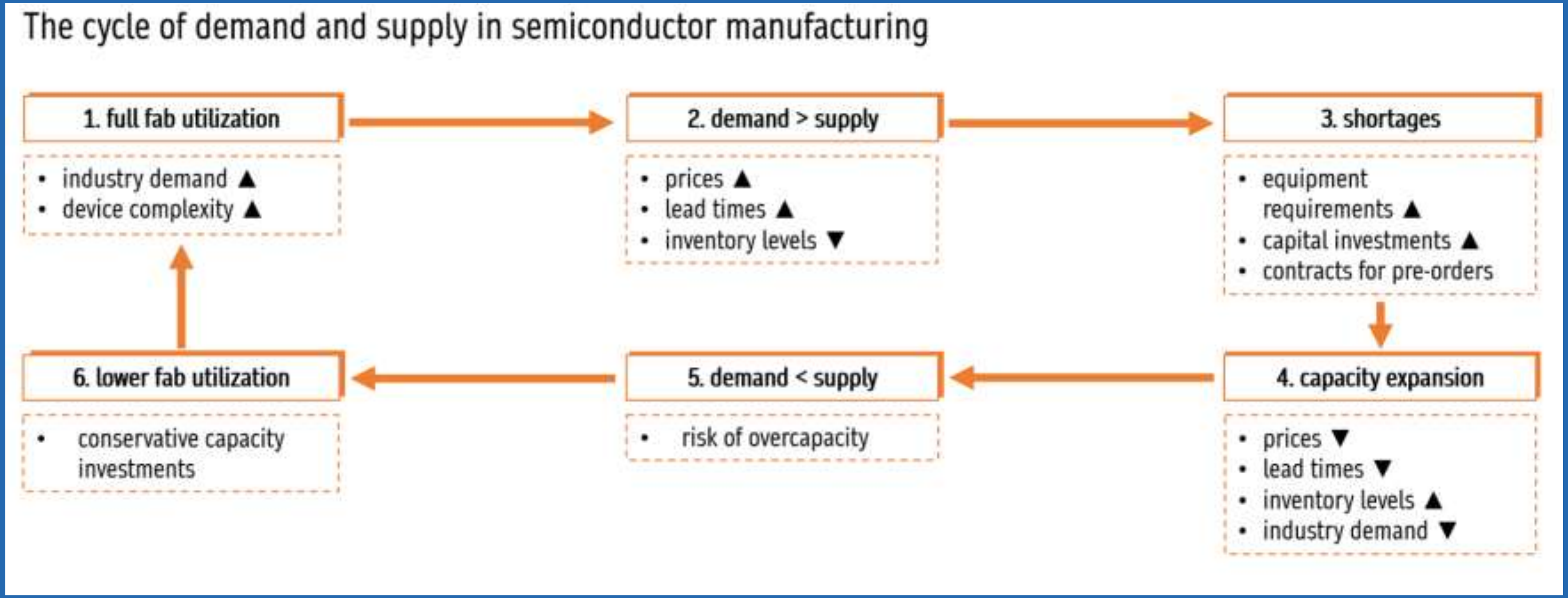
Increasing capacity is not enough



Conclusion-actions to solve the shortage

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- To better cope with demand surges fabs need an economic incentive for overcapacity—not striving for 85% and higher fab utilization rates
- Making the semiconductor value chain more resilient to external shocks certainly involves more transparency in a first step
- Any supply chain that depends on chips, such as the automotive supply chain, will also need to invest in substantial inventory on their own and better supplier relationships
- Governments can certainly provide the right incentives to lessen the high geographic concentration, for example in cutting-edge wafer fabrication and back-end manufacturing, at least to some extent in the long term

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