From the end of the Cold War to mid-2000s the US and China had a symbiotic relationship and a co-dependent trade and economic growth model (Schwartz 2014: 256). With the 2007-2009 financial crisis, limits to this co-dependent model were exposed and US-China relations have been deteriorating since, leading to the confrontational relationship of today. The liberal accommodationist stance towards China under the previous US administrations changed with the start of the 'America First' Trump administration, resulting in a full-blown US-China trade and technology (tech) war from 2018 onwards (Starrs and Germann 2021: 1128).

The semiconductor industry has been squeezed by the US-China tech rivalry (Dollar 2022: 281). The technological dominance of the US semiconductor industry over the past decades has been challenged by firms from Japan and more recently, South Korea, Taiwan and China (Yeung 2022: 55). Besides a tariff war and tougher restrictions on Chinese investments in the US, both the Trump and Biden administrations have issued several China- and semiconductor-related export controls, aimed at China's tech national champions, including Huawei (Starrs and Germann 2021: 1128-1129; Brown 2020: 374).

What are the underlying drivers of the US-China trade and tech conflict? This essay not only aims to answer this pressing question, but it will also assess the consequences of this conflict for the semiconductor industry and the world's most advanced semiconductor firm TSMC.

In assessing the drivers of the tech war and the consequences, this essay will mainly focus on the US semiconductor-related export controls, including the ones that have recently been announced and implemented by the Biden administration in October 2022 (The Economist 2022). This essay is organized as follows.

In the next section, this essay will first argue that offshoring and outsourcing of US production to China, which in turn led to declining manufacturing employment and rising inequality in the US, laid the groundwork for both the election of Donald Trump and the aggressive US trade stance against China (Klein and Pettis 2020; Schwartz 2014; Starrs and Germann 2021). Other sources of the US-China trade conflict, among others uneven private intellectual property protection, unfair competition by Chinese state-owned firms and discriminatory practices relating to public procurement (Hout and Rogowsky 2022:3), are relevant, but they will not be discussed, as this would exceed the scope of this paper.

More specifically, as regards the drivers of the China- and semiconductor-related US export controls, the main argument is that these export controls are intended to protect US national security, to constrain China's technological capabilities and to maintain US technological hegemony (US Department of Commerce 2022; Rikap 2021:76).

Before discussing the short-term and (possible) long-term consequences of the US-China tech war for both the semiconductor industry and TSMC, the third section will give some background on the multi-stage semiconductor manufacturing process, which is needed to fully understand the impact of the tech war. When analysing the consequences for TSMC, Yeung's GPN 2.0 framework (Yeung 2022) and some concepts will be applied. The final part will provide a summary with some conclusions.

Key drivers of US-China trade and tech war

Integration of China into the world economy, job losses, indebtedness and rising inequality in the US

China has been gradually integrated into the world economy over the course of the 1990s and 2000s. US low- and medium-value production was relocated to China, due to its low-wage export-oriented economic model (Starrs and Germann 2021: 1123), providing a large volume of cheap imports to US consumers (Schwartz 2014: 258). To illustrate this: US tech giant Apple outsourced its production and final assembly to Taiwanese firms that, in turn, manufacture in China and export to the US (Starrs and Germann 2021: 1133-1134).

Initially, there were no concerns about China's rise and integration into the global economy, but that really changed with the election of Donald Trump in 2016. The Trump administration was able to draw upon the dissatisfactions of parts of the US population from the "Rust Belt" and other "left behind" US regions, which lost out from outsourcing and offshoring to China and which were (and still are) affected by rising inequality (Starrs and Germann 2021: 1136-1137). The counterparts to these trends in the US were transfers of wealth within China from the working class to the elites, resulting from heavily subsidized export-oriented production, a devaluated renminbi and interest rates that were deliberately kept low, all to the detriment of Chinese consumption of US imports *(*Schwartz 2014: 263; Klein and Pettis 2020:3).

On top of this, Klein and Pettis argue that "*indebtedness in the US was an inevitable consequence*" (Klein and Pettis 2020:3), because China's trade surpluses were recycled into cheap loans to US consumers, buying cheap Chinese goods (Schwartz 2014: 255 and 264). This enabled an American housing bubble and helped create the conditions for the 2007-2009 financial crisis. This exposed the limits of the US-China trade relationship.

Protecting US national security and maintaining US technological hegemony

Since the US-China trade conflict can mainly be considered a tech war (Rikap 2021:76), it is worth analysing the underlying drivers of US decisions, aimed at limiting China's technological capabilities. As mentioned before, this analysis will mainly focus on the China-related US export controls, impacting the semiconductor industry.

A perfect illustration of this is the October 2022 US export controls, which were implemented with a view to "*restricting China's ability to obtain advanced computing chips, develop and maintain supercomputers, and manufacture advanced semiconductors*" (US Department of Commerce 2022). By issuing these sweeping export controls, the US government also aims to restrict the development of advanced semiconductors in China for military purposes.

In addition, as with previously imposed US export controls, the October 2022 export controls have an extraterritorial scope: they do not only affect US and Chinese semiconductor firms, but they also prevent semiconductor firms from third countries from using US-made equipment in China (Goujon et al. 2022). Some advanced semiconductor manufacturers, including TSMC, have nonetheless been granted a one-year export licence (Ting-Fang 2022).

Strikingly, the October 2022 export controls require a licence for any US citizen and resident (green card holders) to work with firms located in China in advanced semiconductor design, research and production, mostly affecting Chinese and Taiwanese citizens (Alden 2022; Sheehan 2022). As I will argue in the next section, this component could significantly affect the further development of the Chinese semiconductor industry.

Besides US national security concerns, more importantly, the recent China-related export controls reflect the Biden administration's real ambition to constrain China's technological capabilities and to defend US technological hegemony (Rikap 2021:76). As mentioned by US National Security Advisor Jake Sullivan, it is about "*maintaining a large of a lead as possible*" in advanced chipmaking (Sullivan 2022).

When talking about China's technological capabilities, the Made in China 2025 (MIC 2025) industrial policy is essential in this regard, as it aims to revamp the Chinese economy from being just an export platform to becoming a technological superpower in key areas by 2049 (Starrs and Germann 2021: 1126-1127). With the MIC 2025 plan, the Chinese government wants to achieve self-reliance in the development of semiconductors (Shattuck 2021: 112).

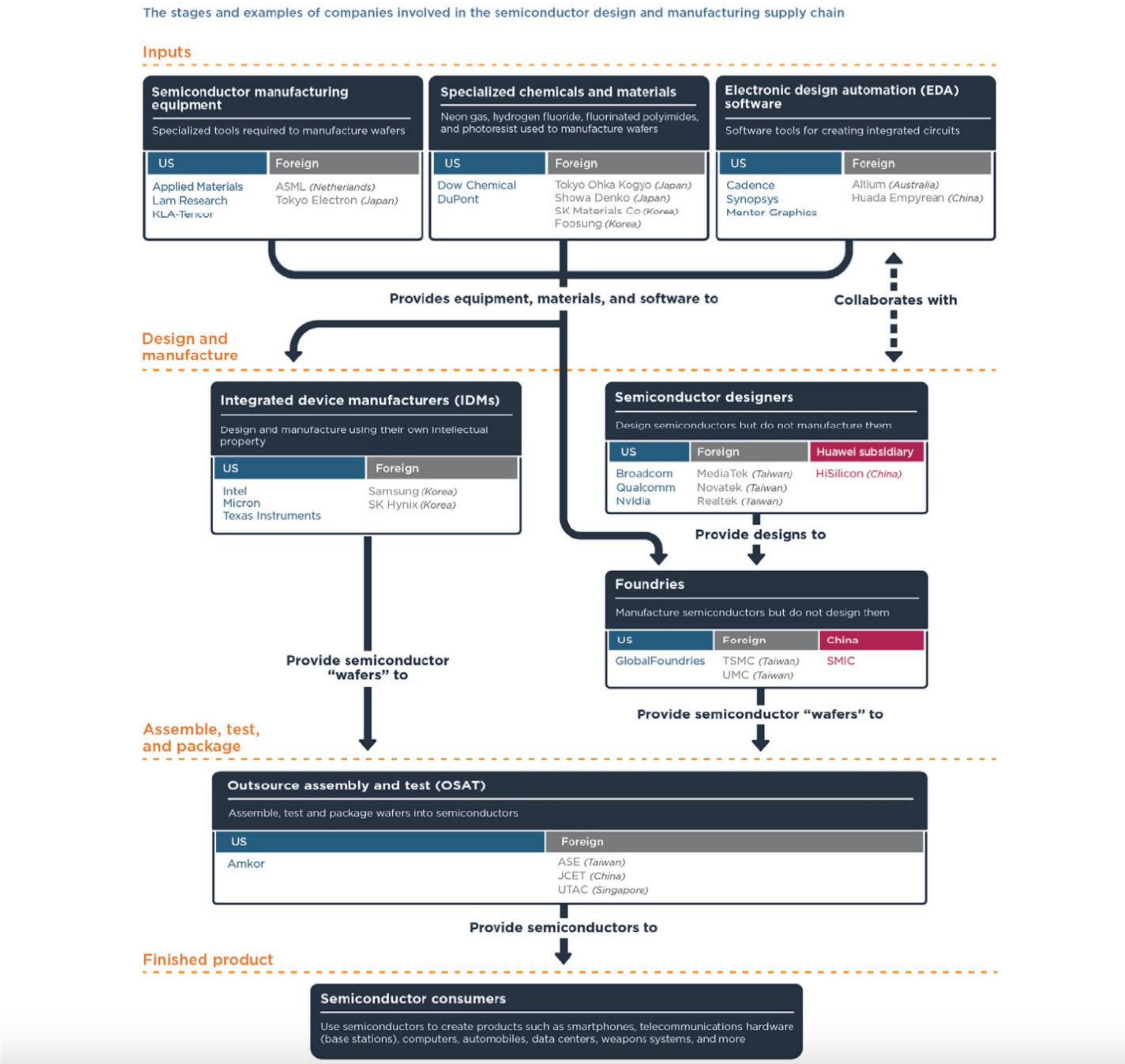
After reading the MIC 2025 plan, one can argue that this poses a challenge to US technological hegemony. However, with exceptions of some sectors, including solar panels, 5G, electric vehicles, it is important to emphasise that the US still has a serious technological edge over China, especially in the development of advanced semiconductors (see more below) (Rikap 2021: 76; Hout and Rogowsky 2022: 7). Huawei has the ambition to develop a domestic chip supply chain for its telecommunication activities (Ting-Fang and Tabeta 2022) and Huawei's chip design firm HiSilicon has been closing the gap, but the Chinese semiconductor industry has still a long road ahead (Schneider 2021). Although China is currently a world leader in building new semiconductor fabs, mainly focusing on older, low-end semiconductors, rather than on advanced ones (Dollar 2022: 281), China is not expected to reach the MIC 2025 goal of producing 70% of the semiconductors consumed in China (Shattuck 2021: 112).

Consequences of US-China tech war for the semiconductor industry and TSMC

Global semiconductor manufacturing supply chain

The various stages of the highly globalised and interdependent semiconductor design and manufacturing process are located in different parts of the world. Using the graph below from C.P. Brown, I will briefly discuss the most relevant stages.

Figure 5. Modern semiconductor manufacturing is a globally integrated multi-stage process



Author: C. P. Brown (Brown 2020:371)

First, the supply of semiconductor manufacturing equipment (SME), which is essential for advanced chipmaking, is controlled by a small number of firms: Applied Materials, KLA and Lam Research in the US; Tokyo Electron in Japan and ASML in the Netherlands (Brown 2020: 372). In terms of semiconductor design, the US remains the dominant region with leading "fabless" design firms, including Qualcomm, Nvidia, and Broadcom (Lee and Kleinhans 2021: 21). Firms that are only manufacturing semiconductors are called "foundries" and the advanced or "cutting-edge" manufacturing process (generally below 10 nanometres (nm)) is mainly done in Taiwan by TSMC, whereas the manufacturing of older, low-end or "trailing-edge" semiconductors is done, among others in China (Lee and Kleinhans 2021:35; Brown 2020: 370).

After the organizational split between the design and manufacturing of semiconductors and with the emergence of the so-called "fabless-foundry model" (see more below), US "fabless" design firms have increasingly been contracting out the manufacturing of advanced semiconductors to "foundries" such as TSMC. (Yeung 2022: 58-60; Brown 2020: 370). The other model is called "integrated device manufacturing" (IDM), whereby firms, most notably Intel and Samsung, are designing and manufacturing their own semiconductors (Brown 2020: 369).

Consequences for the US and China's semiconductor industry

First and foremost, by restricting the industry's access to the design, manufacturing equipment and skilled personnel, semiconductor firms in China will be forced to focus on the development of older, low-end or "trailing-edge" semiconductors, rather than on the advanced, "cutting-edge" ones. Both manufacturing equipment and skilled personnel are, after all, acute vulnerabilities of China's advanced semiconductor supply chain (Lee and Kleinhans 2021:18 and 42; Shattuck 2021: 112-113).

According to a chip firm executive, "*it may be possible to "de-Americanize" chip production, but it is much more difficult cutting ties with leading non-US suppliers*" (Ting-Fang and Tabeta 2022). Compelling evidence of the current loss of skilled personnel is Lam Research's recent decision to cut staff in China that were providing services to manufacturing facilities (White et al. 2022). Similarly, YMTC has urged American staff to quit their positions (McMorrow et al. 2022). This is not a new phenomenon, as Chinese firms, such as HiSilicon, have been faced with reduced access to skilled staff due to US export controls (Lee and Kleinhans 23-24).

A possible upside for China is a potential extension of its market share in the low-end semiconductors segment, given the current high demand for the older generation of chips, which are used in cars, industrial equipment and consumer electronics (Yoon 2022).

Notwithstanding the negative impact on the Chinese semiconductor industry, it is important to stress that US firms are also affected, considering China is the biggest market for semiconductors (Alden 2022; Statista 2022a). For instance, US semiconductor equipment manufacturers LAM Research, Applied Materials, KLA are estimated to lose a significant part of their revenue (Gross et al. 2022).

Another interesting trend resulting from the US-China tech war is that US imports of semiconductors from Vietnam have seemingly increased in the past years, whereas imports from China have declined (Dollar 2022: 278). Some semiconductor manufacturing has thus shifted out of China to Vietnam, as can be seen in the graph below, showing the change in US imports of semiconductors from 2018 to 2021 (Dollar 2022: 287).

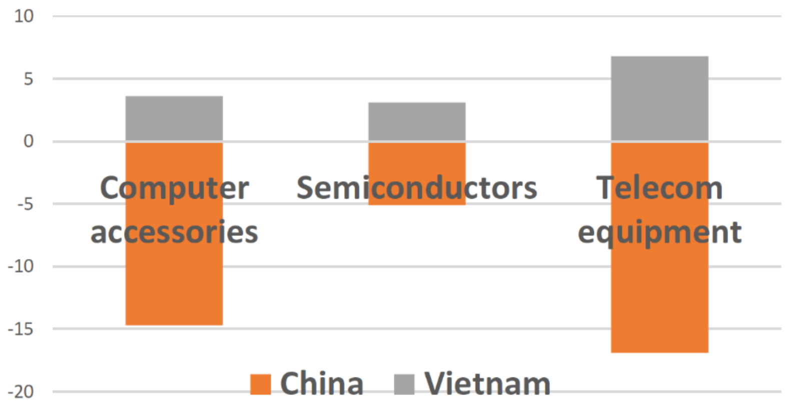


Figure 6. Change in U.S. imports 2018 to 2021 for select hi-tech products (billion USD).
Source: U.S. Department of Commerce, Bureau of the Census.

Source: Dollar 2022

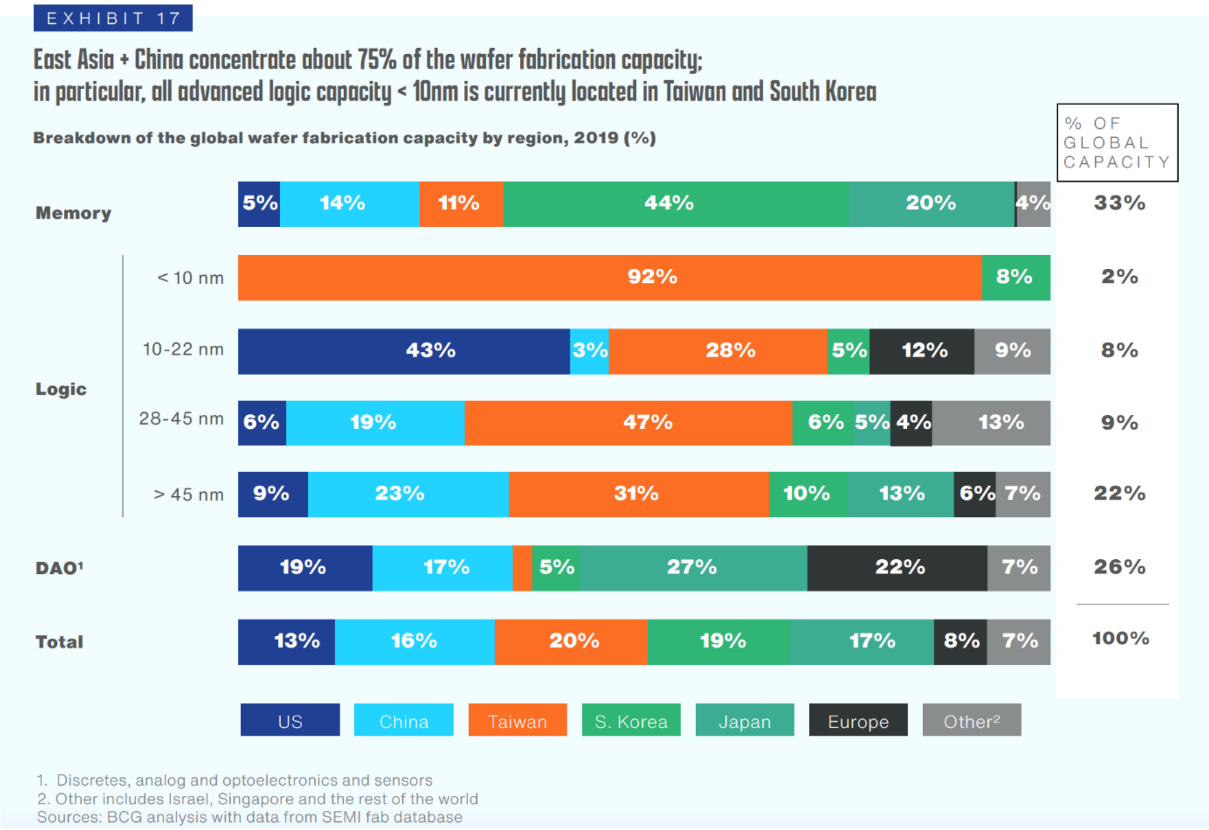
Finally, cutting off China is not likely to address US national security concerns in the long term (Malkin 2022: 551). US export controls have been ineffective before in that regard, with reference to Huawei (Brown 2020: 378). In fact, Yeung argues that the US-China tech war and the latest measures are pushing China to step up its efforts to become self-reliant in the area of semiconductors, in line with the MIC 2025 plan (Yeung 2022: 228-229). But achieving self-reliance will be very difficult and costly. According to a Boston Consulting Group (BCG) and Semiconductor Industry Association (SIA) report, it would cost any country between 900-1,225 billion dollars in investments to build an entire domestic semiconductor supply chain (Varas et al. 2021: 44). Additionally, a country like China, that has been isolated in terms of know-how and equipment, cannot expect to achieve self-reliance in the short term.

Semiconductor GPN in East Asia and consequences of the current US-China tech war for TSMC

TSMC was founded 35 years ago by Morris Chang with the help of the Taiwanese government and the Dutch firm Philips (Brown 2020: 361). It was the first "foundry" and the "fabless-foundry" business model allows TSMC to focus only on advanced chipmaking under contract, unlike other competitors Intel and Samsung. Looking at the causal drivers explaining the shifts in the semiconductor global production networks (GPN) in East Asia, particularly the cost-capability ratio, labour costs are relatively less significant, whereas the capability side, in terms of "fab technology" and "ecosystem capability", is more important (Yeung 2022: 177-185).

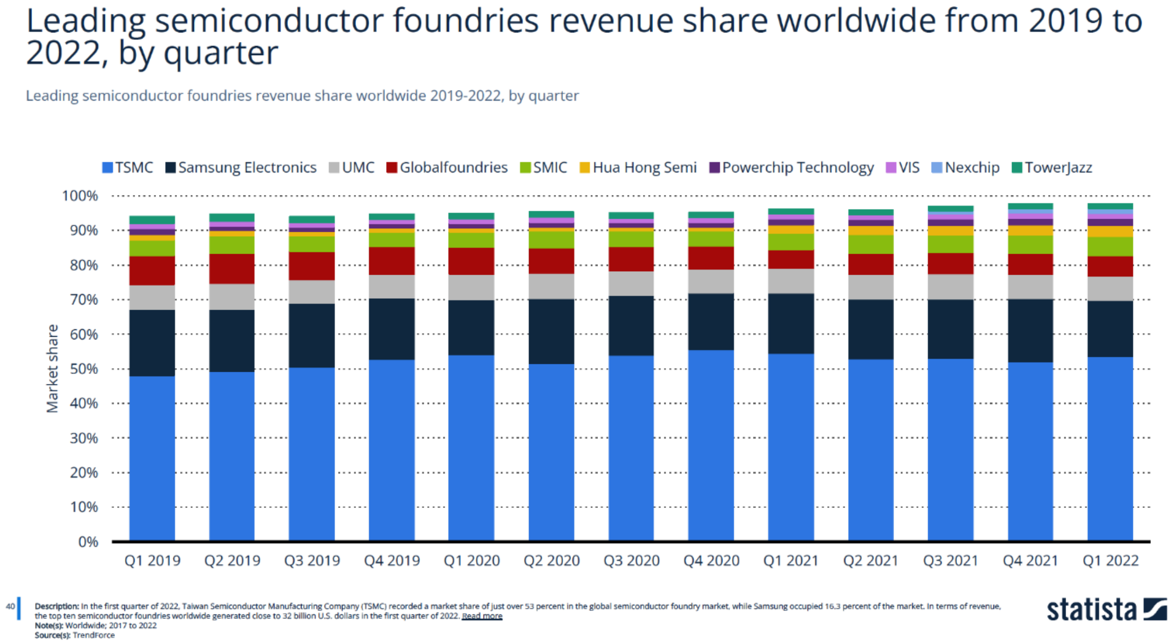
Considering the relatively high costs involved with building and running an advanced semiconductor fab, "financial discipline" has really driven "fabless" and "fablite" firms to set up their production networks in South Korea and Taiwan (Yeung 2022: 192-201). Not only US firms, including Apple – Apple was TSMC's largest customer in 2021 - (Yeung 2022: 199-200), but also the US military is highly reliant on TSMC for advanced chipmaking (Shattuck 2021: 106).

Currently, only TSMC and Samsung can manufacture "cutting-edge" 3 nm semiconductors (Yeung 2022: 162-163). As we can see in the BCG and SEMI graph (Varas et al. 2021) below, showing a geographical overview of semiconductor manufacturing in 2019, advanced chipmaking (below 10 nm) is only located in Taiwan and South Korea, with a market share of 92% for Taiwan.



Source: BCG and SEMI 2021

As this Statista graph below shows, in terms of revenue share, TSMC is the biggest "pure-play foundry" in the world, with over 53% of the market share in the first quarter of 2022.



Source: Statista 2022b

Against this background, it is worthwhile to assess the consequences of the current US-China tech war and to look at how TSMC is mitigating the geopolitical risks, which is one of the causal drivers of the GPN 2.0. framework (Yeung 2022: 201-202).

A good illustration of this is TSMC's 5 nm Arizona fab that has been announced in 2020, in response to US pressure to onshore advanced manufacturing for economic and national security reasons (TSMC 2020; Klinger-Vidra and Kuo 2021: 193). Despite these efforts and costs, TSMC's Arizona fab will likely not be as competitive as TSMC's other fabs in Taiwan, since the production is only expected to start in 2024 and given the Arizona fab's modest full production capacity (Yeung 2022: 232-233; Shattuck 2021: 111). This could even result in higher prices for TSMC's US end customers.

Regarding the recent US export controls, TSMC executive Wei has stated that "the effects are limited and manageable" (Ting-Fang 2022). As mentioned before, the US government has recently granted a one-year export licence to TSMC for its lower-end manufacturing activities in China. Nevertheless, the recent US export controls have hit TSMC, as it cannot assist its Chinese customers with advanced chipmaking. As a reminder, TSMC was forced to stop doing business with Huawei, due to US export controls in 2020 (Shattuck 2021: 108). Moreover, it is perfectly possible that the one-year licence will not be renewed in 2023 (Goujon et al. 2022).

However, TSMC arguably could benefit from the US-China tech tensions and could take over the additional demand for "cutting-edge" semiconductors, because the October 2022 export controls are aimed at restricting China's technological capabilities in advanced chipmaking. Furthermore, because of the development of the 2 and 3nm semiconductors in Taiwan, TSMC will likely be able to widen the technological gap with leading Chinese firms, including SMIC, in the next years (Yeung 2022:224; Shattuck 2021: 115).

Conclusion

This essay has examined the key drivers of the US-China trade and tech conflict and has assessed its consequences for the semiconductor industry and for the world's most advanced semiconductor "foundry" TSMC.

In doing so, this essay argued that the gradual integration of China into the world economy, as well as a combination of job losses, indebtedness and rising inequality in the US, have laid the groundwork for both the election of Donald Trump and the subsequent trade war. Focusing on the US-China tech war, this paper demonstrated that the recent US export controls are more intended to maintain US technological hegemony and the technological edge over China, rather than to protect the US national security. As stated before, the US has still a significant technological edge over China in advanced chipmaking, regardless of China's ambition to achieve self-reliance and to develop an entire domestic semiconductor supply chain, reflected in China's MIC 2025 plan.

Even if the exact consequences of the US-China tech war, especially of the recent US export controls, are, to some extent, still unclear, this essay claimed that the Chinese semiconductor industry will be forced to further focus on the development of older, low-end or "trailing-edge" semiconductors. The October 2022 US export controls have successfully hit China's chokepoints in advanced chipmaking, namely manufacturing equipment and know-how. Consequently, China is expected to step up its efforts in achieving self-reliance, but this will be costly and probably not feasible in the near future.

Apart from the negative consequences for the Chinese semiconductor industry, US firms are also affected and are estimated to lose revenue share. Interestingly, Vietnam seems to have benefitted from the current tech tensions, as US imports of semiconductors from Vietnam have seemingly risen. Unfortunately, this paper was not able to investigate this thoroughly, but this might be interesting for future academic research.

Finally, recent US export controls have hit TSMC's business with China. At the same time, TSMC is expected to capture more market share and to widen the technological gap with its Chinese competitors. In applying the GPN 2.0. framework to the announced TSMC Arizona fab, it became clear that onshoring advanced chipmaking to the US is not as effective as it seems.

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