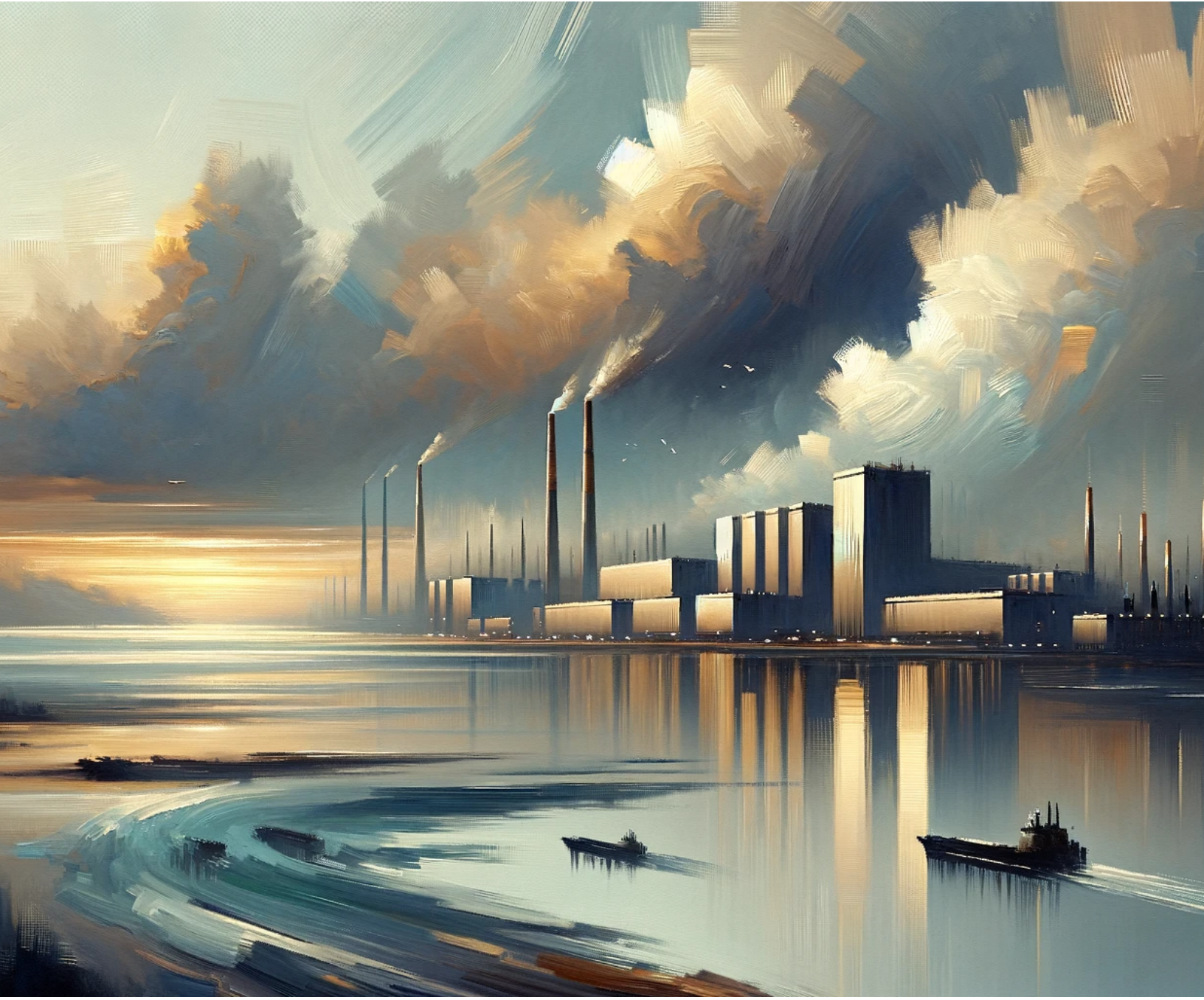

Evaluating Taiwan's Tactics to Safeguard its Semiconductor Assets Against a Chinese Invasion

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Abstract

In the following report, we examine the strategies Taiwan may employ to protect both itself and its semiconductor industry. We discuss four strategies: 1) Scorch the Fabs - Taiwan threatens or executes the destruction of their fabs to deter invasion or deny their use for China - we conclude that the credibility of this approach is limited and intractable; 2) Sabotage the Fabs - leveraging vulnerabilities in the semiconductor manufacturing process, Taiwan subtly impairs key fabrication equipment - this strategy is suggested to be a last-resort, we consider this approach a more credible alternative to demolition; 3) Boatlift Key Staff - boatlifting personnel possessing tacit knowledge could deny China control of the fabs, the success of this strategy hinges upon the accuracy of the evacuating party to identify irreplaceable personnel and the willingness of said personnel to return if needed - given this logistical challenge, we consider this course of action unlikely, and; 4) Indirect Protection of Semiconductor Assets - while it is probable that sanctions would be imposed following an invasion, and that these sanctions would be economically damaging for all involved, we argue that it is unlikely that such efforts could be effectively maintained. Following this thought, we argue that while an invasion would violate international law, this is likely to be disregarded and unlikely to prevent Chinese aggression.

Our report represents an attempt to map out the consequences of a Chinese invasion of Taiwan, a topic that appears to be neglected despite its clear significance to the future of AI research.

I. Introduction

Overview of the 'Century of Humiliation'

In response to an op-ed article discussing the coronavirus, three Wall Street Journal reporters were expelled from China by the Ministry of Foreign Affairs (Wang, 2020). The Chinese Communist Party (CCP) noted explicitly that the expulsion was a direct response to the title of the article, '*China is the Real Sick Man of Asia*' (Manson & Shepherd, 2020). While in isolation, this phrase appears innocuous, it is commonly associated in China with the 'Century of Humiliation' (CoH; Yau, 2020). Beginning with the first Opium War in 1839 and ending with the revolution in 1949, the CoH saw China lose one-third of its territory, suffer external subjugation, be forced into signing unequal treaties and fall into a civil war (Kaufman, 2010).

Before the CoH, China held its position as the regional hegemon in East Asia, signifying its dominant power and influence for nearly two millennia (Danner & Martin, 2019; World Population Review, 2023). However, in Chinese history textbooks, this period is, in broad terms, thought of as pre-CoH, with post-CoH events being taught separately (Jianjun & Shaohua, 2004). As for why an emphasis on the CoH is so pronounced, it is often claimed in the West that such a narrative serves to legitimise the CCP (e.g., Liao, 2013; Charoenmuang, 2022; see also Wang, 2008). In its strongest articulation, the narrative of humiliation credits the CCP with pulling China out of its nadir, re-establishing itself as a major global power in the process. This narrative will remain convincing if the CCP can maintain 'performance legitimacy' (i.e., meet concrete goals, maintain growth, and preserve social stability).

What is the geopolitical and technological significance of Taiwan?

Although it is maintained that the CoH concluded with the ascension of the CCP, traces of that period still linger in the national consciousness. One crucial unresolved matter from that period is Taiwan (Kaufman, 2011). At the end of 2004, China enshrined into law a commitment to use 'non-peaceful means' as a last resort to prevent Taiwan from establishing formal independence should a peaceful reunification be wholly ruled out (Cody, 2005; General Policy Archives, 2005). Its geopolitical significance today is underscored not just by its historical ties but also by its role in the modern technological landscape. Taiwan's production of approximately 60% of all semiconductors (The Economist, 2023) is especially crucial when considering the rapid advancements in the chip-heavy artificial intelligence (AI) industry (Neill, 2023; Hilton, 2022).

This advancement in AI carries both tremendous promise and peril for humanity (Roser, 2022). If misaligned with human values, highly capable and transformative AI systems could inflict catastrophic harm, with some estimating a ten-percent chance of human extinction within the next century (Ord, 2020). Recent breakthroughs in AI development have been catalysed by increased computing power available during training. State-of-the-art (SOTA) AI algorithms now routinely require millions of dollars worth of specialised computer chips tailored to execute deep learning techniques efficiently. For example, training a SOTA natural language model can involve 'AI chips' running nonstop for weeks or months at an estimated cost of over $100 million (Khan & Mann, 2020).

Trying to train advanced/frontier AI models on general-purpose hardware would be prohibitively expensive, costing orders of magnitude more. Access to cutting-edge AI chips has thus become a critical bottleneck limiting the pace of progress on transformative AI applications.

What is TSMC? What does it do? Why does it matter?

The Taiwan Semiconductor Manufacturing Company (TSMC) is a semiconductor foundry that manufactures chips designed by other companies. It is the world's largest dedicated chip foundry (i.e., a company specialising exclusively in manufacturing semiconductors; Campbell, 2021). Chip manufacturing involves the following stages: design, fabrication, assembly, testing and packaging (ATP). TSMC specialises in fabrication, which happens in "fabs" or factories. Fabs contain clean rooms where hundreds of precision manufacturing steps take place to build chips on silicon wafers. This involves expensive lithography machines, robotic arms, and complex chemical processes (Khan et al., 2021). TSMC pioneered the "fabless" model, where chip designers outsource fabrication to a dedicated foundry like TSMC (Sarma & Sun, 2017). In the event of a Taiwanese invasion by China, China has the potential to wield influence over TSMC's vast chip-making prowess, recalibrating its output to serve China's strategic objectives and AI capabilities.

What are the potential impacts on semiconductor production should China invade?

This report examines potential Taiwanese responses to a Chinese invasion aimed at protecting the semiconductor supply. Four strategies are outlined, and their feasibility is discussed: scorch, sabotage, evacuation of essential personnel ("boatlift"), and indirect protection of the semiconductor stockpile by alternative means of defending Taiwan's sovereignty (*see Taiwan's Perspective*). The analysis focuses on the actions Taiwan could take during an invasion to deny China access to Taiwanese semiconductor fabrication facilities and expertise.

II. Overview of TSMC

The Taiwanese Semiconductor Manufacturing Company (TSMC) is a chip foundry focusing solely on manufacturing semiconductor integrated circuits (IC, also called a chip), not designing them. The term “fab” refers to any semiconductor fabrication plant, whether run as part of an integrated device manufacturer (like Intel) or as a pure-play foundry (like TSMC; Nenni & McLellan, 2014).

Building foundry plants is expensive, so instead, clients and fabless companies can benefit from fabrication without capital investment risks by outsourcing their IC designs to foundries like TSMC (Yi-Ching Hsieh et al., 2002).

What is TSMC’s role in global semiconductor production?

TSMC has a monopolistic hold over the chip manufacturing market, particularly in cutting-edge nodes. It controls more than half of the world market for made-to-order chips and nearly 90% of the most advanced nodes. Its strength is evidenced by its enormous trade surplus in integrated circuits (Chiang, 2023). The global reliance on semiconductors for various industries places TSMC at the heart of a critical supply chain (Hille, 2021).

As a global ICT (Information and Communications Technology) assembly hub, China has a huge demand for cutting-edge semiconductors, particularly from Taiwan and South Korea. However, no Chinese firm can rival leading chipmakers in revenue due to technological inferiority. For example, China's largest foundry, the Semiconductor Manufacturing International Corporation (SMIC), lags behind Samsung and TSMC in technology by several generations (Min-Hua Chiang, 2023). By contrast, the United States lags behind Taiwan by one or two generations, if not more, in state-of-the-art microelectronics (Shivakumarand & Wessner, 2022).

Currently, the United States relies on facilities in Taiwan for the production of the most advanced AI-enabling semiconductors that power critical defence systems.

In the event of an invasion of Taiwan, where China potentially gains control over Taiwanese fabs like TSMC, China may redirect advanced integrated circuits (ICs) production for its own strategic purposes. This scenario hinges on some assumptions. Firstly, it assumes the availability and willingness of skilled personnel, such as TSMC and ASML engineers, to continue post-conflict operations. Secondly, it presupposes the uninterrupted supply of key inputs necessary for TSMC's operations, notwithstanding potential global reactions to the conflict, including restrictions on the export of crucial raw materials to Taiwan.

Though Chinese AI labs are devoting some attention to the safety challenges of cutting-edge models (Concordia AI, 2023), the rapid advancement of China's AI capabilities is still a cause for concern. Further advancing its models will require abundant compute and hardware for training. Some Chinese AI models match or exceed GPT-3 in training compute. For example, Inspur's Yuan 1.0 involved a total of 3.53×10^{23} FLOPs for training compared to GPT-3's 3.15×10^{23} FLOPs. However, other Chinese models seem to have been computer-constrained. Huawei's 200B-parameter model was trained for just 6.87×10^{22} FLOPs (Ding & Xiao, 2023)[1].

If China gains control of TSMC's production capacity, it could remove computational limitations on its AI models. This could allow China to rapidly advance its AI capabilities, potentially surpassing the United States.

[1] FLOP (floating point operations) are a measure of the number of such calculations, while FLOP/s (floating point operations per second) measure the rate at which these calculations are performed (Heim, 2023). A petaFLOP/s is then one quadrillion operations per second.

What does TSMC manufacture?

TSMC is at the forefront of semiconductor technology, manufacturing some of the world's most advanced and high-performance chips. Specialising in advanced nodes, TSMC fabricates semiconductor chips with advanced process nodes labelled as '3 nm' and '5 nm'. Note that these labels are more about technological progression and marketing rather than direct measurements of the actual physical sizes of the transistors. The '3 nm' processor boasts a transistor density of approximately 314.73 million transistors per square millimetre, whereas the '5 nm' process has a transistor density of about 185.46 million transistors per square millimetre (Jones, 2020). The manufacturing process for these sophisticated chips is highly complex, requiring state-of-the-art lithography machines designed by Advanced Semiconductor Materials Lithography (ASML Holding). TSMC owns 50% of all ASML machines globally. This gives TSMC a significant competitive advantage and positions it as a global leader in the fabrication of the world's most advanced semiconductor chips. (Cronin, 2022).

The advanced nodes (3, 5 nm) mean that the chips have a high density of transistors, leading to greater computational power. This is crucial for handling the extensive calculations needed during the training of AI models (Sun et al., 2020). Smaller nodes typically allow for faster and more energy-efficient operations, which are critical for training large machine-learning models requiring immense FLOPs. Chips used for AI training, including TPUs and GPUs, inherently utilise parallel processing, a key feature that enhances their FLOP/s metric. This parallel computation is standard across these types of chips, contributing to quicker model training. Parallel processing is not a specialised optimisation but a fundamental aspect of designing these chips. Even in the case of CPUs, which are less commonly used for intensive AI training tasks, parallel processing is generally employed except in rare, power-saving scenarios. Such nodes are not currently produced in

the US or China (Shivakumarand & Wessner, 2022), with Intel and SMIC only being able to produce 7 nm chips (Zhang, 2023; Allen, 2023).

TSMC's substantial ownership of ASML machines not only demonstrates their capability to manufacture high-performance chips at scale but also underscores the critical role of skilled technicians in this process. These advanced machines require constant maintenance and oversight to the extent that they might not function effectively for even a day without someone managing their operation.

How relevant is this to building frontier AI models?

Control over TSMC could have significant geopolitical and technological implications. Securing its access would allow China to control a critical supply chain for semiconductors, enhancing its capabilities in training cutting-edge artificial intelligence (AI) models.

The advanced semiconductor nodes produced by TSMC are important in delivering the computational power needed for training increasingly capable AI models. These nodes, due to their efficiency and capability, significantly enhance the performance of AI systems. However, it is important to recognise that while economically more challenging, training cutting-edge AI models on older nodes, such as those produced by SMIC, is within the realm of possibility. This approach could be viable under specific conditions, including government subsidies or concerted government efforts. Although reliance on older technology incurs a higher cost, the difference may be less than typically assumed, ranging from less than 10 to 20 times the total training cost compared to using the latest nodes.

Control of TSMC could serve dual purposes for China. Economically, it would likely strengthen China's technological infrastructure, spurring advancements that could

drive economic growth. Politically, superior AI models could amplify China's influence globally, intensifying competitive dynamics with the United States.

Potential effects include:

a) Intensified US-China rivalry, as both nations race to develop increasingly advanced AI systems, escalating geopolitical tensions. These tensions would have likely already been amplified by starting the invasion.

b) Higher accident risk from Western countries that try to outpace China if China seems competitive in developing transformative AI systems.

c) Existential risks from China rapidly developing powerful and potentially misaligned AI without sufficient safeguards.

d) Regulatory lag, as China may struggle to enact adequate regulations given the pace of AI advancement enabled by its semiconductor capabilities.

III. How Would China Invade?

Phased Invasion

According to Piers Wood and Charles Fergurson's analysis, the People's Liberation Army (PLA) could benefit from staging the invasion in three distinct phases: initially capturing Quemoy (Kinmen) and adjacent islands, then advancing to the Penghu Islands, and ultimately assaulting Taiwan's west coast (Wood & Ferguson, 2001). This 'stepping-stone' strategy enables the PLA to amass overwhelming numerical superiority at each stage, thereby diminishing the defensibility of the subsequent objective.

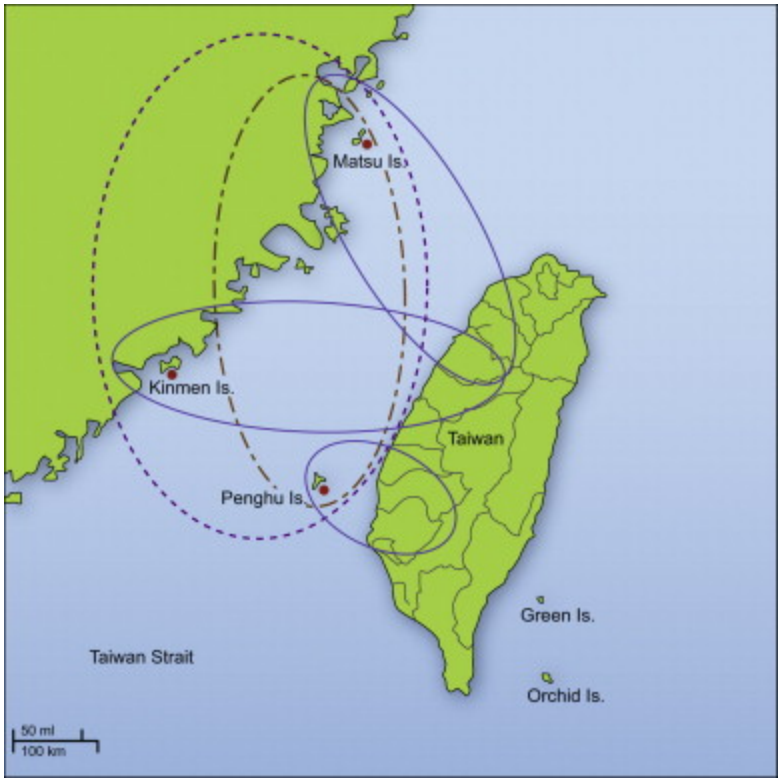

Figure 1: A visualisation of island-to-island relations amongst Taiwan's islands (Baldacchino & Tsai, 2014).

The authors further argue that phased incursion serves multiple strategic purposes beyond military manoeuvring. For instance, Beijing could potentially use the initial phase to foment a domestic 'war fever,' thereby garnering popular support for military projects that would be otherwise unjustifiable in peacetime. Furthermore, intervals between the phases offer a temporal space for substantial improvements in military training based on the experiential learning accrued from the preceding phases. Intriguingly, Wood and Ferguson note that such a gradual approach could also dilute the impetus for U.S. military intervention, given that the preliminary phases may not be perceived as a full-scale assault on Taiwan.

Port Attack

What would attacking the West Coast look like? In addressing the PLA tactics for potential port attacks on Taiwan, Ian Easton (2021) elaborates on six distinct approaches. These approaches, researched by the PLA, are Direct Amphibious Attacks, Indirect Amphibious Attacks, Sea-Skimming Raids, Air Assaults, Horizontal Attacks, and Special Forces Infiltration.

a) The first category, Direct Amphibious Attacks, comes across as straightforward. It envisages PLA naval ships transporting troops into Taiwan's ports using standard shipping routes. One of the key benefits here is speed. Because the ships dock and unload quickly, more units can engage in combat in a timely manner, potentially saving lives and sapping the morale of defenders. However, the caveat is that this approach is contingent on ports being lightly defended or clear of obstacles.
b) Indirect Amphibious Attacks are about landing forces on beaches, flanking the ports, and allowing for pincer movements. Here, the PLA may believe that attacking from flanking positions is more effective when ports are well-defended. This strategy also poses logistical challenges as these forces could be dependent on easily disrupted roadways and may become mired in urban settings.
c) Sea-Skimming Raids, a third option, leverages helicopters, hovercraft, and ground-effect vehicles for a quick, nimble attack. Flying low over the water, they could bypass maritime obstacles.
d) Easton's analysis then discusses Air Assaults, where the PLA could use helicopters to drop troops into strategic positions around ports.
e) The Horizontal Attacks category puts the focus on landing beaches, with the ports considered secondary targets. This method has the advantage of enabling the PLA to bring massive force against well-fortified ports.
f) Lastly, Easton considers Special Forces Infiltration, a high-risk, high-reward approach. Small, elite teams would be inserted into Taiwan covertly to seize critical infrastructure and prepare the battlefield. This could potentially

disrupt Taiwanese command and control, but if discovered, these lightly armed units would be extremely vulnerable.

Assumptions running in this report about how an invasion plays out

This report operates under constraints regarding the forecasting of a potential invasion scenario between China and Taiwan. Predicting the exact course and dynamics of such a complex geopolitical event is beyond the scope of this analysis. Therefore, while we have not developed a detailed model outlining the progression of an invasion, we have tried to identify and suggest optimal timings for each recommended action by Taiwan.

Each strategic action proposed for Taiwan in the event of an invasion is predicated on a general understanding of potential scenarios. These recommendations are based on a range of plausible circumstances in which Taiwan might find itself during a conflict. **The 'ideal' timings for these actions are thus suggested with the strong caveat that they are contingent on the unfolding situation and may need to be adapted in response to the specific developments of any potential invasion.**

These scenarios also assume that the fabs are not naturally destroyed in conflict - which is certainly a possibility during an invasion.

IV. Taiwan's Perspective

What actions could Taiwan take to protect its semiconductor technology from being seized in the event of an invasion being launched by the PRC?

A. Scorch the fabs

In assessing Taiwan's options to safeguard its semiconductor technology from seizure in the event of a PRC invasion, two primary strategies emerge. Firstly, Taiwan could leverage the threat of scorching[2] its own fabs as a deterrence mechanism. This strategy hinges on the premise that the potential loss of such critical infrastructure would make continuing an invasion less appealing to China. Key players in this sector, such as TSMC, MediaTek, and United Microelectronics Corporation, are integral not just to Taiwan but to the global high-tech industry (Lee, 2021). For instance, MediaTek's significant 16% market share in global smartphone sales underlines the far-reaching impact of such a threat (Counterpoint, 2023).

Ideally, the threat of scorching the fabs should be communicated at the earliest stages of a conflict — either immediately at the onset of an invasion or even in the phase where the PRC is overtly threatening an invasion. The rationale behind this timing is twofold: firstly, it serves as an early warning to China about the severe consequences of their actions, potentially altering their calculus before significant resources are committed. Secondly, by establishing this stance early on, Taiwan signals its resolve and willingness to take extreme measures, thereby potentially deterring escalation before it reaches a point of no return.

However, should this deterrence prove ineffective, and China still continues to push on with their invasion, Taiwan can then make good on such a threat, destroying its semiconductor facilities to prevent their acquisition and use by invading forces. While this action would compromise Taiwan's security and economic strength, it could be deemed necessary to prevent the PRC from having access to the fabs and semiconductors (McKinney & Harris, 2021).

[2] Here 'scorching' implies the complete destruction of the fabs.

Problems with scorching

That said, this threat is likely to be perceived as weak and, given the political salience of Taiwan to the CCP, of secondary importance (Chan, 2022). It is likely that destroying the Taiwanese fabs will do very little, if nothing, to dissuade China from continuing an invasion to take control over Taiwan. So then, the only incentive is to ensure that the CCP does not have access to the semiconductors and semiconductor production capabilities in Taiwan, and yet even these have major drawbacks.

In her national day address, the Taiwanese president advocated for a 'calm and confident' Taiwan, suggesting a preference for resilience and strategic fortitude over rash actions (Office of the President Republic of China, 2023). This stance seems at odds with the extreme measure of destroying the nation's semiconductor facilities, a cornerstone of its economy and global technological influence. Under such leadership, Taiwan might instead opt to hold its ground, playing a waiting game to observe how the conflict unfolds. In this critical juncture, Taiwan would likely aim to avoid actions that could be perceived as signs of weakness or desperation, such as the pre-emptive destruction of its own industrial assets.

Furthermore, in a world where Taiwan receives advice from the United States to destroy its semiconductor fabs as a defensive measure, Taiwan could interpret this as an implicit indication of limited direct support during the invasion. Such a scenario could unfold in two ways:

Symbol of Defiance: The destruction of the semiconductor industry might be seen as a potent symbol of defiance against the invading forces. This act could signify a preference for denying resources to the invader, even at the cost of self-harm. However, this approach carries significant risks, including the potential for

long-term damage to Taiwan's economic standing. The fall of Japan's semiconductor industry in the 1990s serves as a cautionary tale; despite recent efforts, Japan has struggled to regain its former prominence in this sector (Tomoshige, 2022).

Damaging Morale: Conversely, the deliberate scorching of Taiwan's semiconductor capabilities could severely damage morale within the country. The CCP might exploit this action in propaganda, claiming that they sought to preserve Taiwan's industry while the 'separatists' chose destruction. This narrative could weaken the Taiwanese public's resolve and undermine international sympathy.

The latter scenario, in particular, suggests that the shock value of such destruction might not justify the immense economic cost and potential political fallout. Furthermore, with diminished material incentives, the United States might find little pragmatic reason to launch a counter-offensive. While other motivations, such as self-preservation and defending democratic principles, remain, it is uncertain whether they would suffice to compel American intervention, especially in the wake of significant industrial loss in Taiwan.

Even if a counter-offensive succeeds, the loss of industry will be felt, making support for the conflict less tractable for the United States. Other motivations will remain (i.e., self-preservation, defending democracy abroad), but it is unclear whether they would be significant enough to entice the United States into defending Taiwan, which then has the secondary effect of preventing the PRC from having access to the Taiwanese fabs (*see Indirect Protection of Semiconductors*).

B. Sabotage the fabs

Rather than outright demolition, Taiwan could pursue more targeted sabotage of key fabrication equipment to impair China's access. Indeed, this appears to be Taiwan's preference, with Chen Ming-Tong (director-general of Taiwan's National

Security Bureau) stating that '*even if China got a hold of the golden hen, it won't be able to lay golden eggs'* (Zheng & Wang, 2022).

Given TSMC's reliance on ASML's lithography equipment and Washington's ban on ASML selling its most advanced machines to China, it appears unlikely that TSMC, under Chinese occupation, would be able to remain on the cutting-edge indefinitely (Meaker, 2022). Even if this were granted, the intricacy of the semiconductor manufacturing process leaves it vulnerable to sabotage. Consider, for example, photomasks (a reflective plate etched with intricate opaque semiconductor patterns that enable the transfer of designs onto silicon wafers). Their production relies on electron beams, lasers, and chemicals - all of which are susceptible to subtle disruption (Syed Rizvi, 2005). Altering mask substrates, tweaking precision mask writers, or tampering with developing chemicals could render masks useless, disrupting device fabrication. Sabotaging extreme ultraviolet (EUV) lithography machines could also prove effective. EUV lithography utilises specialised mirrors and lasers to etch extremely fine patterns, requiring meticulous engineering and conditions (Miyazaki & Anthony, 2019). Contaminating optics or lasers inside these scarce, expensive machines would impair fabs.

Such sabotage of photomasks or EUV lithographers could degrade fabs while avoiding the permanent destruction of facilities. The timing of such sabotage is crucial. Ideally, Taiwan might employ this tactic as a last resort, particularly when nearing defeat[3], to hinder the PRC in a manner similar to a 'scorched earth' strategy. Delaying sabotage until it is absolutely necessary helps avoid prematurely damaging Taiwan's own semiconductor capabilities.

Some uncertainties with sabotaging

[3] *See Open Questions No.2*

However, there is also a scenario where Taiwan might opt for earlier sabotage as a precautionary measure to prevent the PRC from intervening and stopping the sabotage process. In weighing the decision to implement early sabotage as a preemptive measure against the PRC, Taiwan must consider the potential outcomes of the conflict. If there is a belief that victory is achievable, or if there is a reasonable chance of repelling the invasion, the incentive to sabotage diminishes. This is because early sabotage, while serving as a safeguard against Chinese control of the fabs, could potentially set back Taiwan's technological standing if the conflict ends in their favour. In such a situation, an early decision to impair critical semiconductor facilities would have long-term repercussions on Taiwan's position in the global semiconductor market.

Nevertheless, irrespective of the strategic calculations at the governmental level, the actual decision to sabotage may ultimately lie with the engineers and technicians on the ground. These individuals, working within the fabs, possess the technical know-how and the physical access to carry out sabotage. In the face of an invading force, their personal decisions and actions could override official strategies. This means that even if the Taiwanese government decides against early sabotage due to a belief in a favourable outcome, individual engineers might independently choose to disable key equipment as a form of resistance.

C. Taiwan boatlifts key staff

With sustained Taiwanese resistance, a swift Chinese takeover may prove elusive (Cancian et al., 2023). This could create a window to evacuate key personnel working from Taiwanese fabs. Why might this be justified? In a situation where China launches an invasion, it becomes prudent for Taiwan to focus on diminishing the potential gains of the invasion for China, particularly in terms of acquiring the Taiwanese fabs.

Arguably, the tacit knowledge possessed by key employees—knowledge that is difficult to express or readily acquire—is vital for chip manufacturing (Hunt, 2022). Protecting key semiconductor experts might thwart China and its ability to use such fabs should it take control of Taiwanese chip manufacturing facilities.

Evacuating all employees would prove impractical due to the sheer numbers involved and possible interference from the PLA. Nonetheless, pinpointing and relocating individuals with unique expertise in production methods could be more achievable. Their absence may impede China's ability to utilise seized foundries effectively, even with intact machinery. For instance, rather than moving approximately 73,000 TSMC staff members, ensuring the safety of a crucial subset appears more viable and potentially significant.[4]

However, for this approach to be effective, two factors are crucial: identifying personnel whose abilities are genuinely irreplaceable and making certain those skills cannot be easily replaced by specialists from Chinese firms like SMIC. Should such individuals be capable of undertaking the same functions, the impact of such an evacuation would be lessened. The view articulated is that identifying key personnel with rare technical knowledge which cannot easily be replaced could undermine the utility of captured chip fabrication facilities for China.

Note that this relies on Taiwan repelling an invasion for a long enough time and a PRC invasion not being rapid. A swift takeover would enable China to prevent the evacuation of these essential staff. Landlocking the workers in Taiwan would be in China's interest if it wanted to exploit their skills at seised foundries. Hence, a protracted Taiwanese defence is required for this approach of evacuating irreplaceable experts to have potential.

[4] *See Open Questions No.3*

Evacuating Taiwan's semiconductor experts necessitates identifying nearby geopolitically viable destinations. Japan, as the dominant regional power, and South Korea, host to Samsung, appear to be the most feasible proximate nations capable of receiving personnel. Their geographical closeness and advanced infrastructures make both pragmatic relocation choices. Moreover, existing Taiwanese ties with Japan and South Korea could enable smoother transitions amid a rapidly shifting scenario. Both combine proximity for accessible evacuation with sufficient resources to accommodate influxes. These factors, alongside extant diplomatic and economic bonds that could ease coordination, render Japan and South Korea as candidates for temporarily hosting Taiwan's most essential semiconductor technicians; their regional influence, physical infrastructure, and relationships with Taiwan suit them to play such a role.

Problems with boatlifting

The strategic calculus for Taiwan in the event of a conflict with China is complex, particularly regarding its semiconductor industry. While Taiwan's resilience and determination to resist a swift defeat are evident, this resolve must be balanced against the practical considerations of sustaining its economy during the conflict. The semiconductor fabs are not only critical for Taiwan's technological prowess but also form a significant part of its economic backbone. Consequently, the decision to relocate key semiconductor personnel – a move aimed at thwarting China's utilisation of these fabs – comes with its own set of challenges.

This strategy, while effective in impeding the adversary, simultaneously handicaps Taiwan's own production capacity. In the context of a war economy, where funding the conflict is crucial, the reduction in semiconductor output could have significant economic implications.[5] The central question thus becomes: does the tactical

[5] *See Open Questions No. 4*

advantage of hindering an adversary's access to advanced technology outweigh the potential long-term detriment to Taiwan's leading industry?

Furthermore, the post-conflict scenario adds another layer of complexity. Assuming Taiwan emerges victorious, the task of reactivating the fabs hinges not only on the physical restoration of facilities but also on the return of the evacuated talent. The decision-making process for these engineers in the aftermath of geopolitical turmoil is inherently unpredictable. Factors such as attractive opportunities in other countries, personal circumstances stemming from the conflict, and the overall state of the global semiconductor industry could influence their willingness to return and re-engage with the Taiwanese fabs.

Therefore, the strategy of evacuating key personnel, akin to a 'boatlifting' tactic, presents a dilemma. While it might effectively deny critical assets to the invader in the short term, the long-term ramifications for Taiwan's semiconductor industry and economy are substantial. The assumption that these experts would seamlessly reintegrate and revitalise the industry post-conflict may be overly optimistic. Thus, Taiwan must carefully weigh the benefits of temporary invasion impedance against the potential for wider, lasting impacts on its economic vitality and technological leadership.

D. Indirect protection of semiconductor assets

Rather than directly protecting semiconductor assets, an alternative approach is pursuing indirect strategies that defend Taiwan's sovereignty, resulting in the semiconductor assets being shielded. The fundamental aim of the Taiwanese government is to prevent invasion, with actions regarding chips and foundries being the means to that end. If other means can protect sovereignty, the semiconductor assets may be safeguarded without direct action. Indirect approaches open up a wider range of politically and practically feasible options for Taiwan. In essence,

under this view, while the Taiwanese government prioritises sovereignty above all, the protection of the semiconductor sector naturally follows as a byproduct of this focus.

External entities, distinct from the Taiwanese government itself, predominantly implement most indirect protective measures for Taiwan's assets.

Economic sanctions

The power of the economic shock delivered to Russia following its invasion of Ukraine came not so much from the sanctioning of their central bank but rather from the coordination of participating countries (Lubin, 2022). While it is unknown exactly how much of their foreign reserves were lost, hundreds of billions of dollars were likely rendered inaccessible (*See Figure 2*; Abay, 2022). Unlike Russia, which faced severe economic challenges due to the sanctions, China benefits from a significantly stronger economy, which will be less appealing to sanctions. That said, China currently holds in excess of $3.2T in foreign reserves, the largest amount of foreign reserves in the world, and roughly 30% of global foreign reserves (Macro Matters, 2023; IMF, 2023; Dong & Xia, 2022). While in absolute terms, this is undoubtedly a lot, relative to the size of its economy and the potential for large capital movements, this is not necessarily sufficient to safeguard against potential financial instability; hence, China continues to maintain significant control over capital outflow (Lubin, 2022; Mercurio, 2021).

At present, the exact currency composition of the Chinese reserve is kept secret by the People's Bank of China. Of this $3.2T, it is generally assumed that much is held in major currencies (i.e., USD, euro, yen and pound sterling - including holdings of $1.1T in US Treasury securities, $217B in Asset-Backed Securities, and $273B of equities; Tran, 2022). If accurate, much of this will be vulnerable to US and EU sanctions.

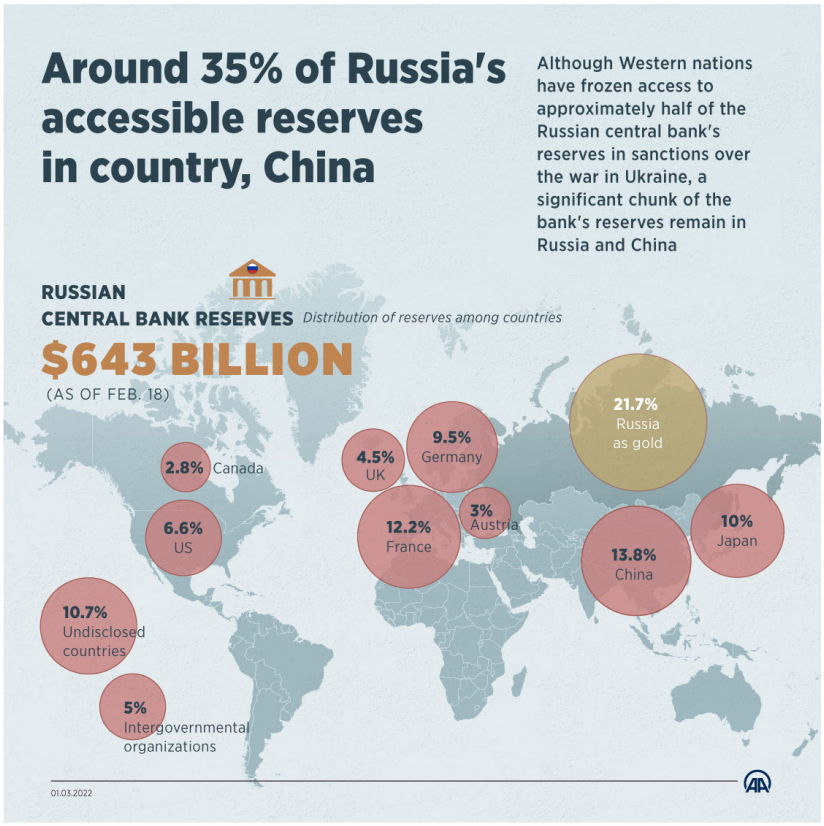

Figure 2: Distribution of Russian reserves among countries (Abay, 2022).

Should China's foreign reserve be largely inaccessible, China will seek to mitigate the financial harm of this action. One approach could be the nationalisation of foreign direct investment (FDI) stock within China, which is valued at approximately $2.1T (Santander, 2023). This would, however, invite retaliatory action, which would put at risk up to $2.75T of their own outward FDI stock (Statista, 2023). China could also consider freezing $1.2T of its domestic stocks and bonds (Feng, 2022). The effectiveness of such a strategy is unclear, with data reflecting the value of foreign domestic stocks and bonds held by Chinese investors being difficult to find. Despite the lack of precise figures, the substantial quotas for the Qualified Domestic Institutional Investor (QDII) program and the Qualified Domestic Limited Partner (QDLP) program, which stood at a cumulative $220.7B

as of June 2023, suggest a significant Chinese interest in foreign markets[6] (Ren, 2023; Zhang, 2023).

Following Russia's precedent, China may halt external debt payments currently valued at around $2.7T (Tran, 2022). Indeed, China may argue that it is willing and able to pay the debt but is prevented from doing so by the actions of the United States government. The majeure clause could be invoked in specific external debt contracts. This would allow for the suspension of obligations if unforeseen government actions at the time of signing make it impossible for the contract's requirements to be fulfilled. However, this would inevitably carry significant reputational costs (Legal Information Institute, 2021).

While these actions may or may not be particularly effective in recuperating capital, they would inflict significant financial harm. Prior economic conflict, albeit on a lesser scale, has shown the potential to cause significant damage; one notable example being the ongoing 2018 Trade War, which, by some estimations, resulted in a GDP reduction for the US and China by 1.35% and 1.41% respectively in its first year (Itakura, 2020). These retaliatory acts could either deter or fragment a unified approach to sanctions, likely far surpassing anything within Russia's capabilities.

Inevitably, such acts will be costly for China. Although China could theoretically achieve self-sufficiency, it needs more natural resources to maintain its current growth trajectory (Navarre, 2023; Ramasamy et al., 2012). Long-term welfare aside, China is not yet self-sufficient, a reality acknowledged by the CCP and President Xi Jinping (Davidson, 2023). Moreover, self-sufficiency in key domains, such as maise production, could be many years away (Luo et al., 2023). Should there be a strong global consensus to impose sanctions, it could lead to significant economic difficulties for China. However, sustaining the actions necessary to have a

[6] These quotas represent maximum permitted investments under these programs rather than actual invested amounts indicating a potential capacity for outbound investments

substantial long-term impact seems improbable. Even in the case of Russia, an easier target, notable economies allied with the United States, such as Turkey, Saudi Arabia, and Thailand, refrained from sanctions (Jiang, 2022). Although the Russian economy is comparable in size to that of South Korea, the sanctions led to substantial disruptions in global commodity trade, potentially contributing to higher global inflation and weaker global growth (Kalish, 2022).

Hence, while it is probable that sanctions would be imposed following an invasion and that these sanctions would be economically damaging for all involved - thereby lending credibility to the threat, it appears unlikely that such efforts could be effectively maintained.

United States: Taiwan Relations Act of 1979

We are making a minor point here about what could cause the US to intervene, but this report does not dive deep enough; we may engage with a 'US perspective' later, perhaps in a second part of this report.

The Sino-American Mutual Defense Treaty (1954) established the U.S. dedication to defending Taiwan and the Penghu Islands[7]. This treaty persisted until 1979 when the U.S. officially acknowledged the People's Republic of China. However, pivotal components of the Mutual Defense Treaty were reincorporated in the Taiwan Relations Act (1979). This U.S. legislation pledges to supply Taiwan with 'defensive weaponry' and sustain the ability to counter any use of force or coercion against Taiwan. Its phrasing is more strategically vague than its 1954 predecessor. Thus,

[7] This Treaty had the following relevant articles: Article II emphasised collaborative endeavours to counter armed assaults and external undermining activities. This meant that both the U.S. and Taiwan would bolster their self-defence capabilities and provide mutual aid when required. Article V was central to the treaty. It declared that an armed assault on either party in the West Pacific would be deemed a mutual threat, necessitating action 'consistent with its constitutional processes' to counteract the shared risk. Article VII permitted the U.S. to position land, air, and naval forces in Taiwan and the Penghu Islands for defence objectives.

the Taiwan Relations Act does not unambiguously promise U.S. military intervention if Taiwan is invaded. However, it establishes some U.S. commitment to involvement in Taiwan's defence, though less unequivocal than its predecessor pact (Brookings, 2004).

International law

Irrespective of Taiwan's official status as a state, Nguyễn (2022) contends that under international law, specifically Article 2(4) of the UN Charter and UNGA Resolution 2625, the use of force in violation of the right to self-determination is prohibited. Therefore, any aggressive attempt to alter Taiwan's governance would constitute a breach of international law. Furthermore, Taiwan is regarded as a stabilised “de facto” state (Chen, 2016), which is argued to possess a comparable right to self-defence, including the possibility of collective self-defence by its allies (Saul, 2021).

This interpretation suggests that the international mandate for states to settle their disputes peacefully extends to interactions with a de facto state like Taiwan. Moreover, the recognition of the Taiwanese as a “people” with a distinct identity entitled to self-determination underscores the island's right to decide its political future free from Chinese pressure. Notably, despite most Taiwanese sharing Han Chinese ancestry with the people of mainland China, the significant period of political autonomy has fostered a unique societal identity.

Nonetheless, historical patterns illustrate recurrent infringements of such legal statutes, questioning their effectiveness as preventive measures. The international community's potential resistance to China's misappropriation of the self-defence clause to justify forceful actions against Taiwan also comes into consideration. However, history has not deterred similar precedents despite the legal complexities potentially undermining China's rationale.

Regarding domestic dynamics within China, it is conceivable that the Chinese Communist Party (CCP) could effectively persuade its populace to view international legal institutions and the United Nations as mere extensions of US influence. This perception could undermine the legitimacy of UN interventions. In the event of a conflict involving a major power such as China, the efficacy of UN resolutions, particularly those subject to China's veto power in the General Assembly, may be significantly constrained, as has been observed historically in conflicts involving major powers.

Ultimately, while a forceful takeover of Taiwan would violate international laws, these have frequently been disregarded and seem intractable in preventing a Chinese aggression.

V. Appendix: Open Questions

1. For China, a swift invasion of Taiwan appears unlikely (Lei, 2021). War would likely be very costly, with economic sanctions presenting a risk to the CCP's reputation (see *Indirect protection of semiconductor assets*; Chan, 2020). With this in mind, it is more likely that China will pursue cross-strait integration by favour, not by force (Chiu, 2020). Naturally, this preference aligns with that of Taiwan; Taiwan's National Development Council has placed the protection of the semiconductor industry as a central policy in its 2021-2024 National Development Plan (National Development Plan, 2020). One avenue to protect its semiconductor stock could be for Taiwan to engage in a gradual, drawn-out process of reunification with China. Given that a primary motive for China's potential invasion is the concept of a 'unified China', as outlined in the *Introduction*, a commitment to a slow reunification

could potentially defuse the immediate threat. How useful/tractable is this to safeguard Taiwan's semiconductor fabs?

2. One uncertainty in this strategy is the proximity of the PRC to gaining control over Taiwan's semiconductor fabs when Taiwan is deemed to be on the brink of defeat. At what stage of the conflict would Taiwan be considered close to defeat, and would this not imply that the PRC is already in a position to take over these critical facilities? Understanding the exact scenario where Taiwan is on the verge of defeat, yet still retains control over its semiconductor fabs is crucial. This assessment is vital to determine the feasibility and effectiveness of employing sabotage as a last resort without it being too late to prevent the PRC from seizing these valuable technological assets.
3. It could be useful to have more work done that looks at the extent to which the specialised equipment or the specialised expertise in fabs are actually hard to replicate or seize.
4. In the context of a conflict, where Taiwan employs strategies to impede an adversary while potentially impacting its own semiconductor production capacity, a question emerges: To what extent would Taiwan be capable of operating its semiconductor fabs under these conditions? Moreover, even if an operation is feasible, how would Taiwan navigate the complexities of exporting semiconductor products amidst the disruptions of war? This question probes the practicality of maintaining semiconductor production and the logistics of export in a wartime economy, balancing the need to fund the conflict against the challenges posed by the conflict itself.

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