Controlling the Uncontrollable: The Migration of the Taiwanese Semiconductor[1] Industry to China and Its Security Implications

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1. Introduction

This paper reports preliminary findings of a case study that explores the relationship between economic globalization and national security. It examines globalization-security linkage by focusing on the strategic aspects of the migration of the chip industry from Taiwan to China as part of the globalization story.

To begin with, the wave of globalization has shaped the way we think about security in terms of its agency and scope. The extensive scope and agency of security threats extending beyond the military and the state have motivated some scholars to call for a wide and multi-sectored agenda for security studies. They are said to have adopted the so-called "widener's approach to security" (Buzan, Waver and Wilde; Ullman; Nye and Lynn-Jones).[3] In addition, given the fluid nature of the notion of security (Wolfers; Friedberg; Allison and Treverton; Nye), Barry Buzan has called for a precise definition of security directed towards specific case studies: "Attempts at precise definition are much more suitably directed towards empirical cases where the particular factors in play can be identified." (Buzan)

Following a widener's approach, namely a broad-based and multidisciplinary approach, I intend to study sectored-based security issues arising from the migration of a strategic sector across the Taiwan Strait, a

[1] Semiconductors refer to solid-state materials with the curious ability to conduct a current somewhere between conductors, such as metals, and insulators.

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[3] "Wideners" intend to broaden the security agenda by claiming security status for issues and referent objects in the economic, technological, societal, political and environmental sectors.

potentially explosive flashpoint in world politics today.

The semiconductor industry in the Taiwan-China context has been chosen for the case study for the following reasons.

First, the industry has demonstrated its significance to the economy and defence of the countries involved since its inception in 1947 (Warner and Raymond).[4] Given the chip industry's significance in broadly defined security terms that involve not only defence but also high technology and economics, the study of the sector and its linkage to strategic issues is of intrinsic interest to researchers. Furthermore, after identifying unique factors at play in the industry, we define security directed towards the chip industry to include economic security, technological security and defence security. The focus of the paper per se will cover technological and defence security. Second, the move of the Taiwanese chip industry to China, as part of the globalization of the industry, unfolds against the backdrop of the tense security relations across the Taiwan Strait and the sensitive US-China-Taiwan co-existence setting. Consequently, it is intrinsically enlightening to analyze the complex security aspects of such economic activities that at times defy the dynamics of the state relationships involved.

However, this interesting subject has received limited attention in the existing academic literature (Yang and Hung).[5] Therefore, the case study is intended to fill in this vacuum first by exploring the scope, speed and cause of the industry migration, and then analyzing the multi-layered security risks thus triggered.[6]

[4] It was marked by the invention of the first transistor in the renowned Bell Lab as a semiconductor device that encodes information in binary form.

[5] Some scholars have analyzed cross-strait high-technology fusion. Others have explored the domestic source of Taiwan's external economic policy formulation regarding the country's chip industry movement to China. Still others have studied the extent to which economic integration across the Taiwan Strait can pose a challenge to Taiwan's national security. None, however, has looked into the extent to which a strategically critical industry migration across the Strait can pose potential security challenges to the countries involved.

[6] As far as methodology is concerned, the research adopts a qualitative case study approach supplemented by related quantitative data. Consequently, more than 130 interviews with industry leaders, officials and experts were conducted, while secondary materials were gathered in the US and Asia. This paper succinctly summarizes preliminary findings based on interviews and secondary materials analyzed so far.

2. Migration of the Taiwanese Chip Industry to China

It is argued that as part of the globalization of the chip industry driven by economic factors, the Taiwanese chip sector has migrated to China on an unexpected scale despite restrictive official regulations at home.

As the semiconductor industry becomes increasingly global, China has emerged as its new centre of gravity as IDMs[7], IC design houses, foundries, assembly and testing companies in North America, Europe and Asia shift part of their operations to China.[8] George Scalise, President of the US-based Semiconductor Industry Association (SIA), dubbed the trend as "a new outsourcing model."[9]

2.1 Scope, Speed and Cause of the Migration

Contributing to part of the semiconductor power shift to China is the wholesale westward movement of the Taiwanese chip industry. The scope of the industry move by relocation, technology transfer, investment and human resource flows is extensive, and challenges previous beliefs that Taiwanese inputs in China's integrated circuit (IC) industry are largely confined to IC manufacturing sub-sector (Howell et al.) Instead, the operation involves almost all of the chief sub-sectors of the industry supply chain, including IC design, fabrication, and backend packaging and testing.

As far as upstream IC design is concerned, some of Taiwan's top IC design houses have established themselves in China to provide "technical support" to local customers with government permission from home. However, some of these China-based operations have illegally involved R&D work outsourced from the company headquarters in Taiwan.[10]

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[7] IDM refers to integrated device manufacturer. This is a company that performs every step of the chip-making process, including design, manufacture, test and packaging. Examples of IDMs are Intel, AMD, and TI.

[8] Marco Mora, SMIC Chief Operating Officer, dubbed the trend as "geographical shifts" in his presentation at SEMICON China, 15 March, 2005, Shanghai, China.

[9] Personal interview, 8 December 2004, San Jose, California, USA. Scalise observed: "What is very different about the China outsourcing was that, first of all, it is not just assembly and test as most of the outsourcing was originally. It has migrated to the front end and towards the leading edge very quickly. As a consequence of that, they are now rapidly moving toward a design capability, which would then call for perhaps a fully integrated semiconductor capability."

[10] Personal interview with a former Taiwanese IC design house president involved in leading the company operations in China, 20 July 2005, Taipei, Taiwan; Personal interview with a Taiwanese IC design house chief, 9 September 2005, Beijing, China;

First-hand research shows that IC manufacturing is by far the most important sub-sector in China's semiconductor industry and the one in which the Taiwanese forces have their strongest foothold. "Calibre, capital and technology from Taiwan have made tremendous contributions to IC manufacturing [in China]," observed Taiwanese-born Nasa Tsai, former President of Grace Semiconductor, and currently leading Sinomos Semiconductor as the firm's president. Both Grace and Sinomos are China-based foundries associated with Taiwan.[11] Interviews with executives from 7 of the top 8 chip foundries in Taiwan and China have provided additional evidence in support of Tsai's observation (Jones; LaPedus). [12]

For instance, China's flagship foundry SMIC is led by Taiwanese American Richard Chang and houses some 650 employees from Taiwan. The firm's Taiwan-born staff accounts for 59 % of its total workforce employed from outside China.[13] Insiders in China's chip industry pinpointed what they saw as the pivotal role that Chang has played as a late-comer into the country. "He is very important. The world microelectronics industry would look at China with an absolutely different light but for Richard Chang's 12-inch wafer fab," revealed a mainland Chinese veteran engineer with more than 35-year experiences in the country's semiconductor industry.[14]

In addition, TSMC Shanghai has established itself as a wholly-owned subsidiary of TSMC headquartered in Taiwan, with approval from the government at home. Furthermore, TSMC's archrival UMC, also headquartered in Taiwan, has "made use of the grey area"[15] in existing government rules to help establish He Jian in Suzhou, China. Similarly in an industry strongly influenced by the Taiwanese is Grace, a

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personal interview with a Taiwanese IC design house vice president, 15 July 2005, Hsinchu, Taiwan.

[11] Personal interviews, 14 September 2005, Ningbo, China.

12 According to IC Insight, as cited by Los Angeles Times on 3 January 2005, these top eight chip makers, ranked by their respective annual revenues as of 2004, include TSMC, UMC, SMIC, Huahong-NEC, ASMC, CSMC, He Jian and Grace. I talked to incumbent or former management executives from seven out of these eight companies with the exception of ASMC. The ranking, however, has changed subsequently with He Jian outperforming many of its challengers on the mainland Chinese soil. According to iSuppli in June 2005, SMIC retained its No.1 position in China's foundry market in 2004 with a 42 % market share. It's followed by Huahong NEC, He Jian, ASMC, Grace and CSMC.

[13] The author's own calculation based on related statistics offered by SMIC. Out of some 8,400 SMIC employees, 86% are from mainland China, whereas 14% are from outside of the country. Among 1,100 employed from outside of China, 650 are from Taiwan, some 200-250 are from the United States. Personal interview with SMIC public relations assistant manager, 30 September 2005, Shanghai, China.

[14] Personal interview with a Chinese chip industry veteran player associated with one of China's earliest state-run semiconductor company, 17 September, 2005, Shanghai, China.

[15] Personal interview with a related top executive, He Jian, 21 September 2005, Suzhou, China.

pure-play foundry in Shanghai.[16] Grace currently houses some 100 Taiwanese employees. The company's Taiwan-born staff accounts for two thirds of its workforce employed from outside China.[17] Finally, some of China-based chipmakers in the second-tier league focusing on 6-inch wafer foundries, such as CSMC[18] and Sinomos Semiconductor,[19] are also run by top management forces originally from Taiwan.

As for packaging and testing, research shows that some Taiwanese packaging and testing firms have undertaken certain operations in China in violation of regulations at home.[20]

So what has triggered the westward migration of Taiwan's chip industry? Perceived market attractions in China, Chinese manpower, and policy incentives in China appear to be key factors.

For example, market and manpower calibre attractions drove UMC to help establish He Jian in China. "We come chiefly because of market and calibre," said a critical player involved.[21] The market factor in question is linked to China's insatiable demand for semiconductors due to its dominance in electronic system production and its fast-growing end-use markets. In 2004 alone, the chip market in China reached $40 billion, making China the second largest IC market in the world with a global share of 22%.[22] F.C. Tseng, Vice Chairman of TSMC, also pointed to market considerations as the key drive propelling TSMC to establish a subsidiary in China: "[We went there] in order to get our market share in the domestic market in mainland China."[23] Perceived market opportunity also drove some Taiwan IC design firms to

[16] This was jointly founded by the Taiwanese tycoon Winston Wang, and Jiang Mianheng, son of former Chinese President Jiang Zemin and Vice-President of the Chinese Academy of Sciences (CAS).
[17] Personal interview with GSMC Chair Zou Shichang, 27 September 2005, Shanghai, China. Zou is a veteran Chinese scholar specialized in ion beams and compound semiconductors. Zou was Jiang Mianheng's predecessor as the chief of Shanghai Institute of Metallurgy, CAS, a research institute associated with one of the earliest efforts in China in conducting semiconductor research and development work.
[18] Personal interviews with CSMC Chairman, 25 September 2005, Shanghai, China.
[19] Personal interviews with Sinomos Chairman and President, 14 September 2005, Ningbo, China.
[20] Personal interviews with industry players, September 2005, Shanghai, Suzhou and Ningbo, China.
[21] Personal interview, 21 September 2005, Suzhou, China.
[22] Presentation, Zhongyu Yu, President of China Semiconductor Industry Association, 15 November 2005, Stanford University, USA. see: < http://sprie.stanford.edu/news/646/ >, accessed 12 March, 2006.
[23] Personal interview, 29 June 2005, Hsinchu, Taiwan.

move westward.[24]

In addition to perceived market drive, local talent availability in China serves as another magnet that attracted Taiwan IC sector westward. In the UMC-He Jian case, the foreseeable shortages of industry-calibre supply at home in the future strengthened UMC's resolve to establish He Jian.[25] Talent pool considerations also pushed Taiwan IC design houses to cross the Strait. This is especially so in the design sub-sector. As system-on-a-chip (SOC) becomes the dominant trend,[26] IC design technological complexity increases. This, in turn, requires a growing number of hardware and software engineers to involve in the increasingly challenging task of IC design. To operate in China beyond functioning as technical support hubs thus enables companies to absorb local talent into entry-level or software work in overall IC design R&D packages as a way of sharing workload within the firm's headquarters in Taiwan.[27]

Secondary to Taiwan IC firms' consideration to migrate to China is related policy incentives that the Chinese government have offered to outside players eyeing to set afoot in China. These incentives include preferential tax treatment and infrastructure arrangements, such as land, water and electricity supplies.

2.2 Means of Violation against Taiwanese State Controls

Certain patterns of behaviour through which some Taiwanese chip firms and individuals have broken the control of government regulations at home in order to move in China are identified as follows:

- In the Name of "Private" Investment: Some industry players in Taiwan have made "private investment" in China's chip industry by either establishing a brand new semiconductor firm or

[24] Personal interview with a Taiwanese IC design house chief, 9 September 2005, Beijing, China.
[25] Personal interview, 21 September 2005, Suzhou, China.
[26] An SOC "incorporates at least one processor, memory and any number of other functions, such as protocol converters, signal processors, and input and output controllers." Greg Linden and Deepak Somaya, "Systems-on-a-Chip Integration in the Semiconductor Industry: Industry Structure and Firm Strategies," Industrial and Corporate Change 12.3 (2000).
[27] Personal interview with a former Taiwanese IC design house president involved in leading the company operations in China, 20 July 2005, Taipei, Taiwan; Personal interview with a Taiwanese IC design house president, 27 October 2005, Taipei, Taiwan.

funnelling funds in support of China-based local IC design houses.[28] The current regulations in Taiwan, however, forbid such moves.[29]

- IC design R&D work operates behind the veneer of approved "technical support" functions in China-based branch offices: Some Taiwanese IC design house branches in China have hired local engineers to take part in some aspects of IC design R&D, such as software-related work, while keeping company core-technology R&D at headquarters in Taiwan.[30] Although "technical support" work by Taiwanese IC design house offices in China is permitted by the Taiwanese government, IC design R&D work is not.

- US citizenship helps: Some Taiwanese individuals who are nationals of both Taiwan and the United States have emphasized their capacities as US instead of Taiwanese citizens while working in China's IC industry. Such moves reflect individuals' attempt to escape from relevant Taiwanese regulations that might apply to them in their capacity as Taiwanese nationals should their involvement in China's chip sector be considered illegal by the government in Taiwan.[31]

- Clandestine ownership change helps: In at least one instance, a Taiwanese chip firm opened its operations in China after the government in Taiwan gave the green light to its related application. It then took over the ownership of a China-based company surreptitiously in order to run related business not yet permitted by the Taiwanese government under the auspices of the purchased firm.[32]

- Move up towards higher-end production without government approval: Some Taiwanese chip firms

[28] Personal interviews with various industry players, August, September and December 2005, China and the United Kingdom.
[29] Personal interview with Chintan Huang, Executive Secretary, Investment Commission, Ministry of Foreign Affairs, 18 August 2005, Taipei, Taiwan.
[30] Personal interview with a Taiwanese IC design house vice president, 15 July 2005, Hsinchu, Taiwan.
[31] Richard Chang's widely-publicized application to relinquish his Taiwanese citizenship while keeping his US citizenship is a case in point. Another instance is that two industry professionals from Taiwan currently heading one of China's chip foundries have put their nationality as "USA" instead of Taiwan in the company's prospectus for the firm's initial public offering (IPO) in 2004. One of them, however, still travels to and from Taiwan holding his Taiwanese passport. Personal interviews with various industry players, September 2005, Shanghai, China.
[32] Personal interviews with various industry players, September 2005, Shanghai, China.

in China move to unlawful higher-end production later in their operation in China, although the firms' permitted investment by the Taiwanese government is confined to lower-end production.

- Firms initially set up in China bypassing existing rules continue to develop beyond official constraints: Current regulations in Taiwan forbid transfers of foundry process technology to China for feature sizes smaller than 0.25 micron and investment in 12-inch wafer fabs in China. However, some foundries in China with Taiwanese input, which were set up by circumventing rules in Taiwan, continue to develop beyond official restrictions. At least two of them have started to use process technology for feature sizes smaller than 0.25 micron in their foundries, while one has started operating a 12-inch wafer fab. These moves clearly go beyond the artificially imposed ceiling by the Taiwanese state.[33]

To sum up, across the chip industry we can see Taiwanese chip firms and individuals turning a blind eye to existing official regulations at home that are designed to control semiconductor-related investment and technology transfer to China. Government rules in Taiwan are simply trying to "control the uncontrollable" in their attempt to curtail the chip sector's westward flight driven by a combination of economic factors. Although Taiwan is far from the only external player that has helped facilitate the Chinese chip industry catch-up process, first-hand research shows that Taiwanese inputs have proved to be pivotal.[34] To what extent can these profit-driven activities across the Strait trigger any security risks for the countries involved? It is to this theme that we shall turn next.

3. Security Implications of the Migration of the Taiwanese Semiconductor Industry to China

There are multiple layers of security ramifications for Taiwan and the United States emanating from the migration of the Taiwanese chip industry to China. They involve economic security, technological and

[33] Although one firm, in particular, has repeatedly referred to itself as an "international" company, its efforts to dilute its Taiwan connection seem futile. Numerous interviewees have described the firm as a blatant example of Taiwanese assistance in China's chip industry catch-up race. Worse still, the company's Taiwanese American CEO has been fined by the Taiwanese government for his involvement in the chip firm and is still fighting to relinquish his Taiwanese nationality.

[34] Qin Sheng Wang, Chair & CEO, China Integrated Circuit Design Center as well as Director Chief, the IC Design Branch of the Chinese Semiconductor Industry Association (CSIA), summed up the point succinctly: "Through various forms of 'internationalization,' calibre and capital from Taiwan have entered mainland China and played important roles. Grace, SMIC, TSMC and He Jian, for example, can not shake off their links to Taiwan… Chen Shui-bian is unable to control the trend. Taiwan has already exerted its impact here." Personal interview, 30 August 2005, Beijing, China.

defence security. Economic security involves the issue of economic independence and industrial competitiveness, but the discussion here will largely focus on technological and defence security.

There are four inter-linked aspects of technological and defence challenges Taiwan and the US face in the wake of the growing chip manufacturing and design capabilities in China, thanks to distinctive inputs from outside including Taiwan. They are: 1) industrial-base concerns; 2) technology-related risks associated with the dual-use nature of the semiconductor technology and the issue of foreign supply of critical chips; 3) concerns reinforced by institutional reforms in China and the Chinese perception of the chip importance to the nation's industrial base, military modernization and modern electronic warfare; 4) risks reinforced by the Taiwan factor.

3.1) Industrial-Base Concerns

With respect to industrial-base concerns, a strong chip industrial base can potentially enhance a nation's defence capabilities given the semiconductor industry's position as "a building block"[35] in modern weapons, communications, navigation, space and battle management systems that all act as force multipliers in modern military affairs.

"The reason why the United States, Europe and Japan have advanced defence technologies is because of the backing of very good industrial bases, part of which depend upon solid IC industry supply chains," observed a veteran industry player.

"After China's open-up policy, if its IC industry along with other system manufacturing industry bases develop quite well, the industrial basis as a whole can become critical drivers that help enhance the country's defence and aerospace technologies," he added.[36]

[35] Personal interview with Michael R. Polcari, President & CEO of International SEMATECH, 7 January, 2005, Austin, Texas, USA.
[36] Personal interview, 9 September 2005, Beijing, China.

The continuous formation of China's chip industrial base is undoubtedly accelerated by foreign inputs in the form of investment, technology and calibre transfers to China from Taiwan and elsewhere. These external elements help China cope with deep-seated structural, organizational and institutional challenges in order to establish a fully-fledged chip industrial base. Significant contributions by players from outside, including Taiwan, can be recognised. For instance, staff training programs in Taiwanese-managed or Taiwanese-owned IC design houses and foundries in China help nurture China's semiconductor talent. Moreover, in the form of the "multi-project wafer" (MPW) shuffle service, these foundries offer subsidies to local customers to assist them with their prototyping efforts by sharing the exorbitantly expensive masks used. These customers include local design houses and research institutes, such as the influential CAS. The MPW service assists local design houses to develop. As foundries in China- that's where Taiwanese inputs seem most obvious- can act as pillars lifting both IC design development and feeding backend packaging and testing with orders, a chip industrial base in China gradually comes into shape.[37] Initial inputs from outside as mentioned earlier unquestionably serve as long-term catalysts in creating a competent chip industrial base in China.

Once a solid chip industrial base comes into shape in China, it can potentially act as a major factor in enhancing the nation's overall defence technology and capability. Resources in a strong industrial base invariably spills over into the military through technological and talent exchanges between civilian and defence sectors of the economy.

For example, cutting-edge firms from the civilian side of the chip industry can not only provide the People's Liberation Army (PLA) with commodity-type standard ICs, but also help design and manufacture critical chip hardware tailored to the need of the PLA. The supply of both advanced commodity ICs and application-specific integrated circuits (ASICs) at home, in turn, can overcome the

[37] Although the foundry-fabless development model seems to dominate current chip industrial landscape in China, partially copying the success story in Taiwan, some favor the IDM model instead, arguing that China will not succeed in the global chip race unless it switches to the IDM model. Huahong CEO David Wang favors the IDM model, whereas SMIC CEO Richard Chang predicts a dual-track development of both fabless-foundry and IDM models. Personal interview with Wang, 24 August, 2005, Beijing, China; personal interview with Chang, 30 September 2005, Shanghai, China.

long-standing risks the PLA has faced from unreliable foreign supplies of critical chip components.[38] It also helps China mitigate the outside influences intent on to slowing down advances in the PLA capability, namely, the US-led export controls designed to curb the inflows of militarily-sensitive semiconductor items, equipment and materials to China.

3.2) Technology-Related Risks

Aside from industrial-base security concerns, the chip industry migration across the Strait also entails technology-related risks. These threats are either reinforced by the dual-use nature of the semiconductor technology or are linked to the issue of foreign supply of critical chips to defence, major infrastructure and intelligence systems.

As Lewis M. Branscomb et al. argued, most technology is dual-use or multiuse. Semiconductors are of no exception. For instance, chips that make precise missile guidance possible can also appear in mobile phones and in automobiles. By the same token, the underlying semiconductor manufacturing process technology to make IC components for consumer electronics and military electronics is fundamentally the same.[39] So if a nation's chip industry catches up to possess cutting-edge manufacturing capabilities to fabricate chips chiefly for non-military end-users (such as mobile phones, PCs and Microsoft Xbox), related process technology can arguably be used to make chips for military applications, depending on the design. China is in the process of catching up in establishing its chip industry, largely to feed civilian end-users, domestic and international alike. However, the cutting-edge technology thus accumulated in China's IC industry can potentially serve the needs of the Chinese military, a possibility reinforced by the dual-use and multiuse nature of semiconductor technology aforementioned (The U.S.-China Security Review Commission).

[38] Several technology journals in China have mentioned the headache of foreign supply of electronic components faced by the nation's defense and aerospace sector.

[39] Personal interview with Michael R. Polcari, President & CEO of International SEMATECH, 7 January, 2005, Austin, Texas, USA.

In addition, the technological development trajectory switch from "spin-off" to "spin-on" adds complexity to the picture.[40] Many technologies critical to military power have been gradually found in the civilian rather than military markets. Partly in response to the rise of commercial availability of high-performance ICs and partly for monetary reasons, the US defence acquisition policy has changed to emphasize buying commercial-off-the-shelf (COTS) components for new system designs. It was lead by the Perry Initiative of 1994. Consequently, the commercial market where high-end chip components are accessible becomes a supply dump for the US defence establishment (Defence Science Board Task Force).[41] Moreover, the US policy change has also spilled over to other countries such as Taiwan[42] and China. Consequently, the proportion of COTS insertion in defence systems on a global scale has increased. "COTS products replace Mil-Spec parts at a rate of 15% per year," although COTS are not recommended for radiation military and aerospace systems, where such insertion can jeopardize the systems in question (Maher). So it is highly likely that defence sectors in other countries, including China, can and will continue seeking high-performance IC supplies from the commercial market for monetary and technical reasons, where possible. So, if China's chip industry becomes a viable designer and producer of high-end chips for commercial use that possess functions far better than those produced by the defence sector, the civilian side of the industry can surely act as a COTS supply pool for the military.

However, the extent of the incentives that the relatively small military market can offer,[43] and the nature of the chip firm ownership in question,[44] can affect IC companies' decision to supply the Chinese

[40] It should be noted, however, that military systems do use many IC components that must incorporate certain technologies for which there is no commercial demand. Those that are outside of widely available commercial industrial capabilities include technologies required for radiation hardening, high-power microwave, and millimeter-wave circuits and special sensor requirements. See Defense Science Board Task Force report, p. 24, quoting Critical Assessment of Technologies, DOD Advisory Group on Electron Devices, 2002.

[41] Subsequent benefits from the US defence acquisition policy change have followed, including marked improvement in cost reduction, performance and development times of microelectronic elements of defence systems.

[42] Personal interview with Abe C. Lin, Director General, Integrated Assessment Office, Ministry of National Defense, 27 June 2005, Taipei, Taiwan.

[43] For instance, SIA President George Scalise asked why China-base private chip firms would go for what seems to be a relatively small defence market at home instead of focusing on the larger and preferably lucrative commercial market. Personal interview, 8 December 2004, San Jose, California, USA.

[44] The firm ownership composition can serve a further modifying factor. For instance, China's government policy in 2000 stipulated that electronic enterprises in the defence industry (*Jungong*) involved in "national security and defence construction" work must be fully owned by the state, and the state must have at least certain shares in enterprises involved in dual-use (*Junmin Liangyong*) technology (Ministry of Electronics Industry). It is not clear, however, whether or not the latest policy change in 2005 regarding defence-civil relations discussed below has overturned the rule mentioned here.

military and aerospace industries.

Finally, the dual-use nature of the semiconductor technology also means that items of certain semiconductor equipment can be used to make chips for both civilian and military end-uses. For instance, the Pentagon's Commerce Control List, points out "national security" significance of plasma dry etching equipment.[45] In addition, Taiwan is identified on the same list as one of the primary supplier countries offering epitaxial silicon wafers. These wafers are deemed of national security significance because they are "potential starting materials" for certain semiconductor devices (General Accounting Office). This is why the Pentagon has requested Taiwan to tighten its export controls to make sure chip equipment re-exported to China from Taiwan would not be used to fabricate chips for military end-uses. Interviews in the US and Taiwan have confirmed the joint security concerns shared by both countries in this regard.[46] However, Stanley T. Myers, CEO of SEMI, added a key qualification to such a possibility: "It's not a pure play. You can use older generation equipment to make very sophisticated products. However, the cost to do that is very high…But in general, if you gonna make them economically and reliable, you need the newer, the new generation equipment."[47]

The second major dimension of technology-related defence risks involves the issue of foreign supply of critical chips to defence and major infrastructure systems.

The fear of foreign dependence on critical IC supplies to the US defence and infrastructure systems is not new.[48] But the cemented pace of globalization of the chip industry rekindles the security concerns involved.

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[45] The list described the equipment as follows: "It is needed for all state-of-the-art electronics, commercial and military" and it "enables production of controlled analog-to-digital converters, field programmable logic devices, and application specific integrated circuits."

[46] Various personal interviews confirm this point. Examples abound, such as the interview with Joseph Wu, Chair of Taiwan's Cabinet-level Mainland Affairs Council, 4 July 2005, Taipei, Taiwan, as well as the interview with Stanley T. Myers, CEO of SEMI, 10 December 2004, San Jose, California, USA.

[47] Personal interview, 10 December 2004, San Jose, California, USA.

[48] Similar misgivings rose in Washington in the late 1980s and the early 1990s in response to Japan's emergence as a key challenger to the US dominance in the global chip industry.

For the US, "trustworthiness and supply assurance for components used in critical military and infrastructure applications are casualties of this migration," cautioned the Defense Science Board Task Force report, with special reference to the migration of chip manufacturing capabilities away from the US (Defence Science Board Task Force). Because Taiwan offers foundry services to the Pentagon and its contractors,[49] the migration of Taiwan's foundry capabilities to China can entail chip supply risks in the same fashion that the Pentagon worries about chip supply assurance when chip manufacturing capabilities move away from the US.

IC parts compromises may occur in several vulnerable scenarios, a move an adversary can make in order to strike at the core of the US defence capabilities at critical times.

First, potential adversaries can play "dirty tricks" when fabricating US-demanded critical non-COTS ICs on their soil. Tricks include the insertion of "Trojan Horses" or other unauthorized design inclusions in unclassified chips used in military applications. These "contaminated" items can subsequently act as "time bombs" to diminish the function of the related chips inserted in critical defence gadgets. "Such backdoor features could be used by an adversary to disrupt military systems at critical times," warned the report. Second, the security of classified information embedded in chip designs may become endangered following the shift from the US to foreign IC manufacturer. Third, although the use of COTS implies less risk to the extent that the destination of COTS in the US defence systems can be kept anonymous, "even use of COTS components may not offer full protection from parts compromise." Worse still, "neither extensive electrical testing nor reverse engineering is capable of reliably detecting compromised microelectronics components." (Defence Science Board Task Force)

Defence experts envisage the possibility of these scenarios against the backdrop of China becoming an increasingly attractive destination for shifting semiconductor capabilities, and at the same time as a

[49] The Defense Science Board report, p. 24; various personal interviews with industry players from Taiwan, August and September 2005, Beijing, China and Taipei, Taiwan.

perceived strategic challenger of the US. Joe Chen, former President of the military-run Chung-Shan Institute of Science and Technology in Taiwan, assessed the likelihood of the insertion of backdoor features: "This is absolutely possible. It falls into the information warfare arena."[50] An engineer formerly involved in military IC designs in the US evaluated the probability of China's move to insert these backdoor features as part of its information warfare tactics: "It is possible, but it is extremely improbable. It's extremely hard to do. China is still far from being able to do it. CIA or FBI surely will play such a trick, but the intelligence organizations in China have no energy for such a task. But this doesn't mean that the Chinese won't do it in 20 years."[51]

The US is not the only one facing these grave scenarios. Given the fact that Taiwan relies on the US for its main weapons system and military IC supplies, Taiwan can face similar security risks from possible IC parts compromises if chips needed for its defence and major infrastructure systems are made in China as a result of the shifting US chip manufacturing capabilities to China. In addition, since Taiwan's IC industry supplies the military at home (however limited in scale), the possibility of such parts compromises can also occur in China-based foundries if one day Taiwan's defence sector is fed with chips fabricated in China as a result of the migration of Taiwan's foundry operations to China.

Aside from possible IC parts compromise risks described above, dependence on ICs fabricated on foreign soil for the US defence applications also expose the US to other security risks. Fear can arise if chip supplies from foreign manufacturers are disrupted by wars or massive natural disasters in the regions in question. A major conflict across the Strait and a massive tremor in Taiwan, which offers fabrication services for the Pentagon and its contractors, can cause similar disruption of IC supplies to the global chip market (Defence Science Board Task Force). Similar IC supply disruption or blockade may also affect Taiwan if chips needed for its defence and major infrastructure systems one day partly or totally depend on fabrication services in China.

[50] Personal interview, 9 August 2005, Taipei, Taiwan.
[51] Personal interview, 7 September.

As chip capacity shifts to potential adversary countries, the US defence establishment also fears that the countries in question can impose a government-led "reverse-ITAR" pressure on the US by denying the US access to critical chip technologies. In the same fashion that Japan denied sales of advanced chip manufacturing tools to the US in the late 1980s, potential adversary countries where advanced foundry services are currently building up their momentum can refuse to offer foundry services to the US in the future (Defence Science Board Task Force).

Finally, if one assumes that leading-edge R&D tends to follow the migration of manufacturing, current chip manufacturing capability shift to potential adversary countries can trigger related R&D to follow suit. Close cooperation between talented IC manufacturing process engineers and designers underpins successful leading-edge chip development. The loss of process engineers to countries where advanced manufacturing dominates, followed by possible shift to the same destinations by IC designers, can thus risk the US technological leadership in advanced chip technologies. This, in turn, would affect both the commercial and defence product development process (Defence Science Board Task Force). A former Pentagon official said the above risk scenario is not impossible.[52]

Faced with the foreseeable defence concerns, the US government has adopted measures to mitigate these risks. Actions have been taken to ensure sources of foreign supplies to be trustworthy. A deal has been sealed between the US government and IBM to use the firm's "Trusted Foundry" service in Vermont[53] to assure leading-edge custom circuit supply at home.

However, an additional complication is unavoidable. That is, the Pentagon does not acquire components at the IC level. "Individual circuits are most often specified by the designers of subsystems; even system

[52] Personal interview, 18 January 2005, Washington DC, USA. The official-turned defence company staff said the migration of IC design naturally follows the shift of chip manufacturing to offshore sites. Since IC design is critical to defence capability development, the migration of IC design capabilities, following in the footstep of chip manufacturing technology shift to potential adversary countries, can help the countries in question catch up in due course. The US technological and defence superiority will thus be put to test.

[53] Various interviews, December 2004 and February 2005, San Francisco, Washington DC, New York, USA.

primes have little knowledge of the sources of the components used in their system-level products. Any DOD acquisition plan to address IC trustworthiness and availability must focus on defence suppliers as such as DOD itself," suggested Defense Science Board Task Force report (Defence Science Board Task Force).

3.3) Concerns Reinforced by Chinese Institutional Reforms and Perceptions

The industrial-base concerns and technology-related security risks are further reinforced by pertinent institutional reforms in China and the Chinese perception of the chip importance to the nation's industrial base, military modernization and modern electronic warfare.

First of all, State Council directives and General Armaments Department and COSTIND regulations in 2005 have triggered a major institutional change in China's defence-civilian sector relations. On 28 May, 2005, the Chinese government announced that it would be issuing new licenses for weapon development and production, and some would be given to civilian firms. This policy change has opened up opportunities for civilian firms to take part in the defence sector. It formally smoothes the channel through which resources can transfer from the civilian sector to the defence sector (Drewry and Edgar).

This institutional change in China, echoing the global trend to enhance the use of COTS items in defence systems, can arguably reinforce the security concerns aforementioned. Unquestionably, the policy change certainly exemplifies part of the core spirit in Deng Xiaoping's "16 Character Policy" that has guided the Chinese military for the past few decades. That is, it is essential to use the profits and resources in the civilian sector to maintain the military (*yimin yangjun*) and to integrate the military with the civilian (*junmin jiehe*). The timing of the new institutional reform reflects Beijing's determination to systemically absorb resources from the private sector in a fast-growing industrial base to directly benefit the defence sector. So the reform kick-started mirrors the official attempt to maximize the national technological base upon which China can modernize its military infrastructure by integrating the civilian and the non-civilian. In addition, the change indicates Beijing's recognition of the dual-use and multiuse nature of most

technologies including semiconductor technologies.[54]

So far, no Taiwanese-managed or Taiwanese-owned chip firms in China interviewed said they have supplied chips to the Chinese military and aerospace industries. The institutional reform, however, may open the door for China-based firms with Taiwanese input to sell suitable ICs to the Chinese defence industrial complex because of strong incentives or coercion if the Taiwan link is not considered as an obstacle in the eyes of the Chinese defence establishment.[55]

Parallel to the Chinese institutional change is the Chinese perception of the semiconductor importance to the nation's industrial base, military modernization and modern electronic warfare. This perception arguably fortifies the state-led resolve to build a solid chip industry with both economic and strategic objectives in mind, thus further reinforcing the defence-related security risks faced by the US and Taiwan described above.

Zhongyu Yu, President of CSIA, said the development of the semiconductor in China is not limited to science and technology consideration: "Not merely to science, the semiconductor industry is also a very important industry to economic development and defence security."[56] Microelectronics is also on a list of enabling technologies recognized by the Chinese defence industrial complex as critical to the PLA modernization process. In 1993, for instance, the Chinese space and missile industry formed a research academy dedicated to the development of space-qualified microelectronics (Stokes). The notion of "chipping" as part of the modern electronic warfare scenario is not foreign in PLA writings. Secondary materials show that the Chinese military is aware of the previous US tactics of using backdoor devices in IC components in its conduct of war, while advocating similar measures in future warfare.

[54] For example, when a COSTIND official announced the policy change last year, he used a chip firm story to illustrate Beijing's recognition of advanced technological resources embedded in the private sector at home.

[55] Some interviewees from the industry said it's unlikely that the Chinese military and aerospace establishment will ask Taiwan-related firms to design or fabricate chips for sensitive end-uses due to "national security" considerations. But at least in one instance, a Taiwanese IDM was contacted by a Chinese aerospace institute on the possibility of making radiation-hardened chips used under aerospace environments. The deal was not sealed in the end. Personal interview, an industry player, December 2004 and August 2005, USA and China.

[56] Personal interview, 2 September 2005, Beijing, China.

3.4) Concerns Reinforced by the Taiwan Factor

The above security ramifications can be further complicated by the Taiwanese chip industry migration to China because of the following elements.

First, language and cultural proximity, as well as "great China complex" in the minds of some Taiwanese semiconductor professionals working in China can jointly help facilitate informal and formal know-how transfers and flows between veteran Taiwanese industry players and their Chinese counterparts. In a sector featured by "learning by doing," language and cultural proximity helps accelerate the speed and efficiency of knowledge transfers. It is exactly in this aspect that inputs from Taiwan play a distinctive role in helping China catch up in the global IC race in comparison with their counterparts from Europe, Japan and the US. First-hand interviews support the argument strongly.[57] The so-called "great China complex" which partially fortifies some Taiwanese's resolve to move westward to set afoot in the Chinese chip industry can further speed up these people's contribution to the Chinese IC industrial base. Taiwanese American David Wang, former Applied Materials senior vice president who shifted to Shanghai to work as CEO of Huahong group in 2005, said this group of people decided to parachute into China in the hope of seeing a strong China in the future.[58] These intangible factors can jointly accelerate the formation of a solid chip industrial base in China in due course.

Moreover, continuous political tension across the Strait has functioned as a structural constraint that prevents any Taiwanese official presence in China. It is thus impossible for Taipei to implement its relevant policies. For instance, how can the Taiwanese government find out if equipment shipped to China is for civilian use without on-site inspection? Doubts have been cast on the effectiveness of the Pentagon-led effort to inspect China-based chip firms on-site in an attempt to ensure no military end-use is serviced by these firms. The annual inspection, after all, is a move legally endorsed by Beijing and

[57] Personal interview, R&D vice president, a chip design house, with abundant experiences in operating the firm's branch office in China, 19 August 2005, Hsinchu, Taiwan; personal interview, a Taiwanese IDM branch office chief, 24 March 2005, Shanghai, China.

[58] Personal interview, 24 August 2005, Beijing, China.

Washington.[59] In contrast, the lack of such an inspection by Taiwanese officials in China makes any unilateral policy in Taipei void. The very ineffectiveness of the Taiwanese policy implementation naturally presents a serious pitfall in official regulations that can be circumvented by private sector actors if they wish to avoid exorbitant punitive cost for the companies in question.[60]

Third, although the Taiwanese chip sector largely designs and produces chips for civilian end-use, Taiwan's strong IC design and manufacturing capabilities can potentially cater to the need of the defence sector, where possible. Some in Taiwan have offered foundry services to the Pentagon, its contractors and Taiwan's defence establishment although the business accounts for a small part of the companies' revenues. In the same fashion, Taiwan's foundry and design services can be made available to defence sectors elsewhere including China. [61]

In sum, a semiconductor industry is a building block for a strong defence although chips constitute partially to defence capability enhancement as other factors such as system integration and software capability are equally, if not more, important. The migration of the Taiwanese chip industry to China, like the shift of chip manufacturing basis away from the US to the offshore site of China, can help accelerate China's leap in the global chip race. Given the chip industry's importance to a nation's defence and economic clout, countries which have uneasy political and defence relations with China but are driven by economic forces to help China to catch up in the chip race through efforts led by the private sector naturally face enormous security risks. Taiwan and the US are countries most affected by the latest global chip industry changing dynamics with the spotlight focusing on China as an ambitious latecomer. The

[59] Personal interviews with US officials, March 2005, Shanghai, China.

[60] The matter is further complicated by political infighting at home. A draft bill proposed by the current government to prevent the island state's sensitive high technologies and creative talent from flowing to mainland China has been buried in legislative committee proceedings for numerous parliamentary sessions as of now due to inter-party strife. This domestic politics dimension was even ignored or misread by the US defence establishment when a related report expressed optimism that the bill would sail through the legislature with ease before it could effectively control sensitive high-tech flows to China (Defence Science Board Task Force). Thus reviewed, Taiwan arguably becomes the weakest link or the "Achilles' Heel" in any attempt to curb transfers of advanced chip technologies and much-needed investment to China.

[61] In one instance, a Taiwanese foundry has served a dubious local IC design house in China. The firm is a spin-off of a state-run research institute which has the track record in supplying analog ICs for gadgets inserted in China's *Hangtien* project *ShengZhou No.5*. It is not clear, however, where the chips fabricated in the foundry finally ended up. See a company data base tracking customer-supplier relations, a related technology journal article and a pertinent Chinese-language news report.

case explored so far brings us back to our starting point: what does the story teach us about the intricate ties between globalization and security? It is to this theme that we shall turn next.

4. Conclusion

The case study shows that in an age of globalization, economic forces can be so compelling that any attempt by state actors to curb cross-border economic movements can be limited or futile- even in the name of security. The dilemma faced by the Taiwanese state facing a powerful chip industry's resolves to move to China seems to support a "state in retreat" school of thought in globalization-related literature. The challenges faced by the US government, to a lesser extent, tell a similar story. This study further demonstrates how a broad-based multidisciplinary approach to security studies can bring about a contextually rich discussion of the linkage between security and economic globalization. Chip industry migration across the Strait entails potential security risks for the countries involved, but we may be blind to the complex layers of security risks in question without a sectoral-based multidisciplinary analysis. It is perhaps time to embrace a widener's approach to the study of security.

Reference

Allison, Graham, and Gregory F. Treverton, eds. Rethinking America's Security: Beyond Cold War to New World Order. New York: W.W. Norton & Company, 1992.

Buzan, Barry. People, States and Fear: An Agenda for International Security Studies in the Post-Cold War Era. 2nd ed. Hemel Hempstead: Harvester Wheatsheaf, 1991.

Buzan, Barry, Ole Waver, and Jaap de Wilde. Security: A New Framework for Analysis. London: Lynne Rienner Publishers, 1998.

Defence Science Board Task Force. High Performance Microchip Supply. Washington D.C.: Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, 2005.

Drewry, Seth, and William Edgar Edgar. "China Gambles with Private Sector." Jane's Defence Industry 1 November (2005).

Friedberg, Aaron L. "The Changing Relationship between Economics and National Security." Political Science Quarterly 106.2 (1991): 265-76.

General Accounting Office. Export Controls: Rapid Advances in China's Semiconductor Industry Underscore Need for Fundamental U.S. Policy Review. Washington DC: General Accounting Office, 2002.

Howell, Thomas R., et al. China's Emerging Semiconductor Industry. San Jose: Semiconductor Industry

Association and Dewey Ballantine LLP, 2003.

Jones, Terril Yue. "Spying Case Underscores Rivalry of Asian Chip Firms." Los Angeles Times 3 January 2005, Online ed.

LaPedus, Mark. Updated: China's Foundry Industry to Slow in 2005. 14 June 2005. EE Times. See: <http://www.eetimes.com/showArticle.jhtml?articleID=164302952>. Accessed on 14 June 2005.

Linden, Greg, and Deepak Somaya. "Systems-on-a-Chip Integration in the Semiconductor Industry: Industry Structure and Firm Strategies." Industrial and Corporate Change 12.3 (2000): 545-76.

Maher, Michael C. “Can COTS Products Be Used in Radiation Environments?” December 2003. COTS Journal. See: <http://www.cotsjournalonline.com/home/printthis.php?id=100089>. Accessed on 12 August 2005.

Ministry of Electronics Industry. Yearbook of China Electronics Industry 2001. Beijing: Electronics Industry Publishing House, 2001. (in Chinese)

Nye, Joseph S. Bound to Lead: The Changing Nature of American Power. New York: Basic Books, 1990.

Nye, Joseph S., and S. Lynn-Jones. "International Security Studies: A Report of a Conference on the State of the Field." International Security 12 (1988): 5-27.

Stokes, Mark A. China’s Strategic Modernization: Implications for the United States. Carlise PA: Strategic Studies Institute, US Army War College, 1999.

The U.S.-China Security Review Commission. Chapter 10: Technology Transfers and Military Acquisition Policy, Report to Congress of the U.S.-China Security Review Commission-the National Security Implications of the Economic Relationship between the United States and China. July (Washington D.C.: U.S. Government Printing Office, 2002).

Ullman, Richard H. "Redefining Security." International Security 8.1 (1983): 129-53.

Warner, Jr., and M. Raymond. "Microelectronics: Its Unusual Origin and Personality." IEEE Transactions on Electron Devices 48.11 (2001): 2457-67.

Wolfers, Arnold. "National Security as an Ambiguous Symbol." Political Science Quarterly 67.4 (1952): 481-502.

Yang, Chyan, and Shiu-wan Hung. "Taiwan's Dilemma across the Strait." Asian Survey 43.4 (2003): 681-96.