china perspectives

Controlling the Uncontrollable

The Migration of the Taiwanese Semiconductor Industry to China and Its Security Ramifications

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This paper summarises preliminary findings of a contextually rich case study that explores the link between globalisation and security. Following a broad-based and multidisciplinary widener's approach, the paper explores the strategic aspects of the migration of the Taiwanese semiconductor industry to China as part of the globalisation processes. Based on a triangulation of interviews and secondary data analysed thus far, the paper first explores the drivers of industry migration and the means by which Taiwanese state regulations are violated by related business operations. It then contends that these profit-driven activities have triggered multi-layered strategic challenges for Taiwan and the USA involving technological and defence security. Four inter-linked aspects of the strategic ramifications are analysed: (1) industrial base concerns; (2) technological risks associated with the dual-use nature of chip technology and the foreign supply of critical chips; (3) concerns reinforced by mainland Chinese institutional reforms and perceptions; (4) risks reinforced by the Taiwan factor. The paper concludes by calling for an embrace of a widener's approach to the study of security.

Introduction

This paper reports preliminary findings of a qualitative single case study that explores the relationship between globalisation and security by focusing on the strategic aspects of the migration of the chip industry from Taiwan to China.

From the outset, the wave of contemporary globalisation has shaped the way we think about security in terms of its agency and scope. The extension of security threats beyond the military and the state have motivated some scholars to call for a broad-based and multidisciplinary agenda for security studies, known as the "widener's approach to security." [(2)]

Following this approach, my study focuses on the sector-based security issues arising from the migration of the strategic semiconductor industry across the Taiwan Straits, a potentially explosive flashpoint in world politics today.

Semiconductors, globalisation and security

Setting the Scene

The significance and relevance of the case study lie in the following aspects: First, the semiconductor industry has demonstrated its significance to the economy and defence of the countries involved since its inception in 1947, marked by the seminal invention of the transistor at the world-renowned Bell Labs. Following Moore's Law, the empirical observation Gordon E. Moore made in 1965 forecasting that the number of transistors on an integrated circuit (IC) for minimum component cost doubles every 24 months, the growth of the semiconductor industry over the past few decades has been largely associated with the ability to steadily shrink the transistor and increase its speed without increasing cost. [(3)] Today, chip components available at the end of the industry supply chain permeate consumer electronics, personal computers, communications, automobiles, aerospace, and military end-uses (see Fig. 1). Global sales of semiconductors

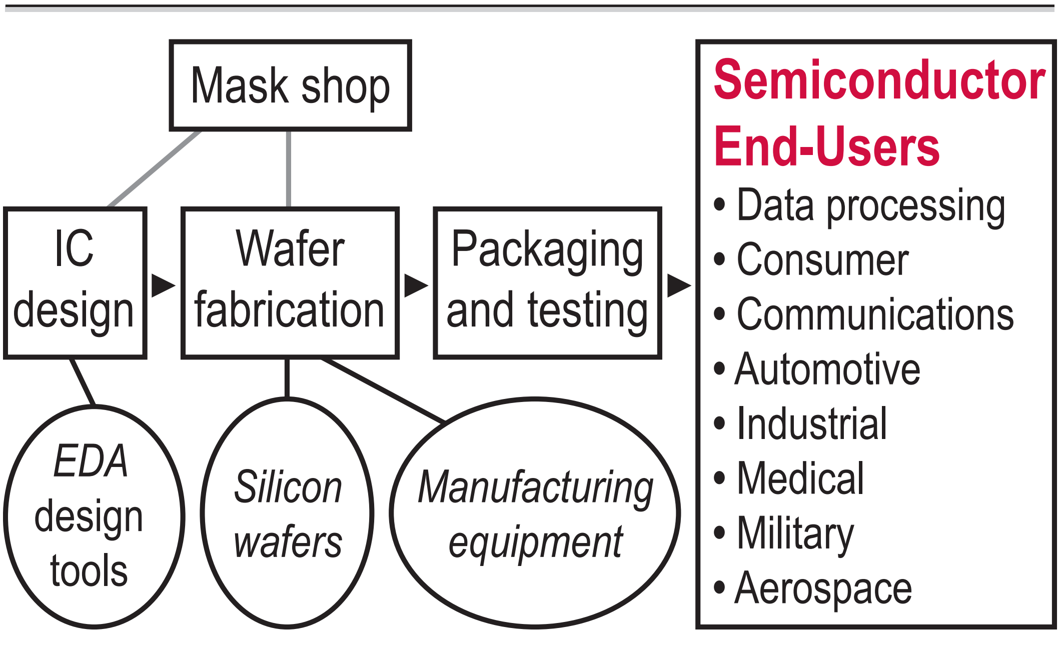
1. The author would like to express her deepest gratitude for useful comments and feedbacks from Prof. Peter Nolan, Dr. Jean-Pierre Cabestan, Dr. Fiorella Allio, Dr. Frank Muyard, an anonymous reviewer of the article, a member of the American defense industry who wishes to remain anonymous, as well as colleagues at the Centre of International Studies, University of Cambridge.

2. "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. See, for example, Ann J. Tickner, "Re-Visioning Security," in Steve Smith (ed.), *International Relations Theory Today*, Cambridge, Polity Press, 1995, pp. 175-97; Barry Buzan *et al.*, *Security: A New Framework for Analysis*, London, Lynne Rienner Publishers, 1998; Joseph S. Nye and S. Lynn-Jones, "International Security Studies: A Report of a Conference on the State of the Field," *International Security*, vol. 12, n° 4, Spring 1988, pp. 5-27.

3. Moore's original statement can be found in Gordon E. Moore, "Cramming More Components onto Integrated Circuits," *Electronics Magazine*, 19 April 1965, pp. 114-117. A reprint of the article is published in *Proceedings of the IEEE*, vol. 86, n° 1, January 1998, pp. 82-85.

4. Semiconductor Industry Association, "Global Chip Sales Hit Record $247.7 Billion in 2006," press release, 2 February 2007. See http://www.sia-online.org/pre_release.cfm?ID=426, accessed 9 March 2007.

Figure 1. Basic Stages of the Semiconductor Industry Supply Chain



reached US$247.7 billion in 2006, with sales growth largely driven by popular consumer products such as MP3 players and cell phones. [4] Its significance to the United States economy and national security, for instance, was grasped in a report by the US National Advisory Committee on Semiconductors in 1989. The report contends:

> *The semiconductor industry is strategic to America. The industry is the foundation of the information age, playing a crucial role in the consumer electronics industry, and other industries that have a high electronic content in their products. America's national security also depends on the semiconductor industry. United States and NATO forces rely on the technological advantage of advanced semiconductors to offset the numerical superiority of potential adversaries.* [5]

Second, the very existence of various related regulatory regimes at the multilateral, bilateral, and unilateral level involving the three major state actors further bespeaks the strategic nature of the semiconductor industry. At the multilateral level, the Wassenaar Arrangement, established in 1996, includes semiconductor items, equipment, materials, and technology on its Control Lists. As updated at its December 2005 Plenary meeting, Wassenaar identifies its criteria for the selection of dual-use items as follows: "Dual-use goods and technologies to be controlled are those which are major or key elements for the indigenous development, production, use or enhancement of military capabilities." As such, current Wassenaar regulations stipulate that lithography equipment capable of "producing a pattern with a minimum resolvable feature size of 180nm or less" is controlled, and intended export to China requires permission from pertinent Wassenaar member states. [6] In 2005, the US gave the green light to the sale of 65nm process technology to Semiconductor Manufacturing International Corporation (SMIC, *zhongxin*) in Shanghai, as SMIC CEO Richard Chang (*Chang Juching*) announced at the Third China International Industry Exhibition in Beijing on 24 August 2005.

5. For a brief history of the invention of the transistor, see R. Warner, "Microelectronics: Its Unusual Origin and Personality," *IEEE Transactions on Electron Devices*, vol. 48, n° 11, 2001, pp. 2457-2467. The quote cited appeared in Robert Kuttner, *The End of Laissez-Faire: National Purpose and the Global Economy after the Cold War*, New York, Alfred A. Knopf, 1991, p. 223.
6. Wassenaar's function has been arguably marred by the lack of a "no undercut" rule and other factors. Under a "no undercut" rule, a Wassenaar member would agree not to permit the export of any listed item(s) that have been officially denied an export license by another member within a specific period. For Wassenaar's Control Lists updated in December 2005, consult the following link: http://www.wassenaar.org/controllists/WA-LIST%20(05)%201%20Corr..pdf. Accessed 15 March 2006. For the lists updated in December 2006, consult the following link: http://www.wassenaar.org/controllists/WA-LIST%20(06)%201%20PDF%20Version.pdf. Accessed 15 January 2007.

At the bilateral level, a pact between Washington and Beijing in 1998 paved the way for US official end-use visits in China, consisting of pre-license checks and post-shipment verifications that often involve US official inspections of China-based semiconductor firms and agencies on the ground. In April 2004, the two governments exchanged letters vowing to strengthen arrangements for such visits. For Taiwan, a memorandum of understanding was sealed with the US on export controls in 1990. In March 2005, US officials held their first educational workshop on export controls for Taiwanese counterparts in Taipei.

At the unilateral level, the US Department of Commerce is the authority for administering and enforcing export controls of dual-use items, including advanced semiconductor components, equipment, materials, related software, and technology that fall into various sub-categories under Category Three of the Commerce Control List (CCL). As for Taiwan, the government ended a total ban on semiconductor investments in China in 2002, allowing China-bound investments to establish a limited number of 8-inch wafer fabs using 0.25 micron process technology. On 29 December 2006, the government further lifted restrictions on China-bound investments in establishing 8-inch wafer fabs using 0.18 micron process technology. According to current Taiwanese regulations, Taiwanese firms are forbidden to conduct IC design R&D work, to invest in 12-inch wafer fabs, or to invest in high-end packaging and testing operations in China. (7)

Thirdly and finally, the Taiwanese chip industry's migration to China, as part of the continuous globalisation of the industry, has unfolded against the backdrop of tense security relations across the Taiwan Straits, uneasy Sino-US security ties, and the sensitive US-PRC-Taiwan co-existence. While the US and Taiwan maintain what some US scholars, such as Johnston, dub as a "quasi military" alliance relationship, the geopolitical links between the US and China are far from those of allies, partly due to the widely perceived role of the US as a guarantor of Taiwan's security. (8) The unresolved sovereignty dispute between China and Taiwan further complicates the geopolitical interactions among the three actors. Given the strategic nature of the industry and the tense US-PRC-Taiwan security links, it is important to analyse the extent to which the sectoral globalisation across the Straits might affect these triangular security relations.

It should be noted that the chip industry's strategic nature has ensured its unique position in the discussion of economics, security, and international relations, not merely in the current and ongoing context of the chip sector dynamics involving the US, PRC, and Taiwan. Similar studies of the interplay between the chip industry, economics, and security have also been conducted in other contexts, such as the USSR-US confrontation during the Cold War, and Japan's ascendancy in the global chip race during the late 1980s and the early 1990s. (9)

Some definitions: Globalisation and security

Before proceeding to empirical data on the case study in question, it is important to defined globalisation and security, as used here.

Many academics have described globalisation as controversial, vague, slippery, or ill-defined. (10) Among a proliferation of definitions of globalisation, one strand focuses on economic globalisation and the other on non-economic globalisation. In this paper, globalisation is defined broadly to encompass both economic and non-economic elements, and as such sees globalisation processes as multi-dimensional phenomena with multiple causes and

7. Decisions by the US Commerce Department whether or not to grant licenses are determined on a case-by-case basis, and the department refers certain applications for inter-agency reviews and recommendations that may involve the Department of State, the Pentagon, and the Department of Energy. In Taiwan's case, the Ministry of Economic Affairs is in charge of the semiconductor equipment export controls as part of the existing high-tech trade controls mechanism. The National Science Council is the authority for talent and technology export controls. Taiwan trade officials interviewed say Taiwan vows to follow the Wassenaar Arrangement based on the Washington-Taipei pact, although it is not a member of the multilateral pact. See interviews with Taiwan trade officials and US trade and defense officials in 2005, government websites and related government press releases; for example, the US Department of Commerce website at http://www.bis.doc.gov; "Statement on the Policy of Easing Restrictions on China-bound Investments in Producing Eight-inch Wafers Using Taiwan's Wafer Technologies," Mainland Affairs Council, Taiwan, 29 December 2006, available at http://www.mac.gov.tw/english/macpolicy/easing.htm. accessed 15 January 2007.
8. Alastair Iain Johnston, "Is China a Status Quo Power?" *International Security*, vol. 27, n° 4, 2002, pp. 5-56.
9. On the USSR-US case, see, for example, Beverly Crawford, *Economic Vulnerability in International Relations: The Case of East-West Trade, Investment, and Finance*, New York, Columbia University Press, 1993; J. Fred Bucy, "Technology Transfer and East-West Trade: A Reappraisal," *International Security*, vol.5, n° 3, 1980-1981, pp. 132-151. On the US-Japan case, see John W. Kanz, *An Uncertain Shield: U.S. Microelectronics and Foreign Dependencies in a Globalized Industry*, PhD Dissertation, The Claremont Graduate University, 1991; Daniel I. Okimoto *et al.*, *The Semiconductor for Competition and National Security*, Stanford, Northeast Asia-United States Forum on International Policy, Stanford University, 1987; Theodore H. Moran, "The Globalization of America's Defense Industries: Managing the Threat of Foreign Dependence," *International Security*, vol. 15, n° 1, 1990, pp. 57-99.
10. David Held *et al.*, *Global Transformations: Politics, Economics and Culture*, Stanford, Stanford University Press, 1999, p.1; Jonathan Perraton, "The Scope and Implications of Globalisation," in Jonathan Michie (ed.), *The Handbook of Globalisation*, Cheltenham, Edward Elgar, 2003. pp. 37-60; Paul Hirst and Grahame Thompson, *Globalization in Question: The International Economy and the Possibilities of Governance*, 2nd ed., Cambridge, Polity Press, 1999, p. 17.

outcomes. Arguably, it is based upon this conception of globalisation that some scholars have divided globalisation into separate dimensions, including the economic (trade, finance, production), the military, the political, and the cultural, among others. (11)

This paper primarily focuses on the economic and military aspects of globalisation pertinent to the semiconductor industry. The economic globalisation of the sector encompasses trade, finance, and production, but the particular focus of the study in question is on the globalisation of chip production primarily through cross-border activities of multinational corporations (MNCs) and concurrent or ensuing flows of technology, calibre, foreign direct investment (FDI), and other forms of capital. By borrowing the definition of Held et al., production globalisation refers to "the stretching of corporate activity and business networks across the world's major economic regions." In its most visible and institutionalised form, it involves the operations of huge MNCs organising and managing cross-border business activities through the ownership of plants, outlets, or subsidiaries in different countries. (12) It is worth noting that the globalisation of production spearheaded by MNCs can also drive cross-border workforce migration, especially of highly skilled expatriate managers. In this sense, some have argued that cross-border activities of MNCs have become central to almost all aspects of globalisation, far beyond mere production. (13)

As for military globalisation, Held et al. define it as "the process (and patterns) of military connectedness that transcend the world's major regions as reflected in the spatio-temporal and organisational features of military relations, networks and interactions." Among the three indicators of military globalisation that Held et al. have proposed, it is the global arms dynamic, particularly the trans-nationalisation of the defence industrial base through which armaments production technologies and military capabilities are diffused on a global scale, that is linked to the chip industry, given the assumption that the sector constitutes part of a nation's defence industrial base. (14)

As for security, the notion has been a focal point of contention among security studies scholars, with some viewing it as rather contested and ambiguous. Moreover, the three major paradigms in international relations, Realism, Liberalism, and Constructivism, have defined the notion of national security differently. (15) The conventional Realist account of national security focuses on the protection of territorial integrity and even core values of states, with military might as the primary, if not only, source of power and means to ensure national security. Conventional Liberals remain state-centric, as their Realist counterparts do, while emphasising the need to embrace non-military areas of national security. The state and military centrism of conventional Realism evaporates in the Constructivist conception of national security, whereby the major unit of analysis, referent objects of security, and scope of security differ radically. These disparate accounts of security do not necessarily follow the paradigmatic divide, however. A relevant example is that some scholars from all three camps, with varied motivations, have called for broadening the notion to encompass non-military elements to a greater or lesser extent.

Considering the fluid nature of the concept of security, this paper subscribes to Buzan's belief that a precise definition of security should be directed towards specific case studies. In other words, "attempts at precise definition are much more suitably directed towards empirical cases where the particular factors in play can be identified." (16) After identifying unique factors at play in the empirical case study of the semiconductor industry, security directed towards the chip sector is defined to include economic security, technological security, and defence security.

11. Robert O. Keohane and Joseph S. Nye, "Globalization: What's New? What's Not? (And So What?)," *Foreign Policy*, n° 118, 2000, pp. 16-17; D. Held *et al.*, *Global Transformations: Politics, Economics and Culture*, *op. cit.* Other dimensions of globalisation include social globalisation, migration of people, environmental globalisation, and technological globalisation.
12. MNCs also outsource production to small and medium enterprises (SMEs) abroad, thus resulting in the creation of global production networks, in which the chief task for MNCs does not involve ownership but rather regularised contractual relationships. D. Held *et al.*, *Global Transformations: Politics, Economics and Culture*, *op. cit.*, pp. 236-237.
13. John Salt, *International Movements of the Highly Skilled*, Paris, Directorate for Education, Employment, Labour and Social Affairs, International Migration Unit, OECD/GD, 1997, pp. 9-10 and pp. 16-18; Grazia Ietto-Gillies, "The Role of Transnational Corporations in the Globalisation Process," in J. Michie (ed), *The Handbook of Globalisation*, *op. cit.*, pp. 140-144.
14. D. Held *et al.*, *Global Transformations: Politics, Economics and Culture*, *op. cit.*, p. 89.
15. Arnold Wolfers, "National Security as an Ambiguous Symbol," *Political Science Quarterly*, vol. 67, n° 4, 1952, pp. 481-502; Graham Allison and Gregory F. Treverton (eds.), *Rethinking America's Security: Beyond Cold War to New World Order*, New York, W.W. Norton & Company, 1992; Aaron L. Friedberg, "The Changing Relationship between Economics and National Security," *Political Science Quarterly*, vol. 106, n° 2, 1991, pp. 265-76; Barry Buzan, *People, States, and Fear: An Agenda for International Security Studies in the Post-Cold War Era*, Hemel Hempstead, Harvester, 1991, p. 7; David A. Baldwin, "The Concept of Security," *Review of International Studies*, n° 23, 1997, pp. 10-12; Steve Smith, "The Concept of Security in a Globalizing World,, in Robert G. Patman (ed.), *Globalization and Conflict: National Security in a 'New' Strategic Era*, London and New York, Routledge, 2006, pp. 33-55.
16. B. Buzan, *People, States, and Fear, op. cit.*, p. 20.

The notion of economic security is defined to include economic competitiveness and economic independence, and is seen as a direct contribution to the exercise of national power. [17] In concrete terms, since the 1960s, when the US semiconductor sector became the first to go abroad on a large scale, the economic security ramifications of the globalisation of the semiconductor industry have often encompassed fear of decreased economic competitiveness, job reduction, and "hollowing out" effect, as well as the loss of technology and skilled personnel. These concerns are certainly not foreign to the current Sino-US and China-Taiwan contexts.

The notion of technological security or techno-security, according to Simon's definition, refers to "a concept dealing with the perception and enhancement of the technological assets of a nation or a firm," which arguably presumes that technology is an important element in national security. [18] In concrete terms, the absolute and relative decline of a nation's semiconductor industry, which is often seen as a key indicator of a nation's high-technology development, has often triggered security concerns.

The notion of defence security refers to the Realist military-centric and state-centric definition of national security, whereby the state's territorial integrity is chiefly maintained through its military capabilities, and alliances are seen as "the highest end" in anarchy, the prerequisite for the pursuit of other goals such as profit, power, and tranquillity, as Waltz has argued. [19] In concrete terms, the semiconductor industry links to defence security as it underpins the modern military clout of a nation by supplying chip components directly for high-tech military end-uses central to modern battlefield operations.

The focus of this paper covers aspects of technological and defence security implications of the Taiwanese chip sector migration to China, while leaving the theme of economic security to subsequent writings.

Existing literature and methodology

In regards to existing academic literature on the current and ongoing context of the chip sector dynamics involving the US, PRC, and Taiwan, systemic studies of the security ramifications arising from the sectoral migration across the Straits have been insufficient. Many academic studies have focused on the economic dimension of the industry migration or the pertinent policy debates in Taiwan's domestic political arena. [20] Few, however, have systematically analysed the security dimension resulting from the economic movement. [21]

For example, although the US Defense Science Board (DSB) in 2005 published an exceptionally relevant task force report examining potential security risks the US might face with the continuous shift of US chip manufacturing to China, the study remains US-centric. Its references to the Taiwan dimension are meagre and even erroneous, and it fails to take into account the PRC domestic policy environment, which is arguably indispensable in assessing potential security risks for the US. Like many studies of the economic aspect of the industry migration across the Straits, the DSB study is also inadequate in that it is not based on first-hand field research data that might offer researchers information not readily available in secondary materials. My study attempts to fill this void in the existing literature by bridging international political economy and security studies and by engaging in multiple levels of analysis of the subject matter based on field research results.

17. Borrowing Romm's conception of economic security, a nation's economic competitiveness refers to the degree to which a nation produces goods and services that meet the demand of international markets while expanding the real incomes of its citizens; moreover, the nation's economic independence equips the nation with the flexibility to make decisions free from foreign dictates or foreign economic coercion. As for the conception of economic security as a direct asset to the exercise of national power, it is based upon Borrus and Zysman's definition of economic security, which refers to a nation's "ability to generate and apply economic resources to the direct exercise of power, or to shape indirectly the international system and its norms." Joseph J. Romm, *Defining National Security: the Nonmilitary Aspects*, New York, The Council on Foreign Relations, 1993, pp. 78-80; Michael Borrus and John Zysman, "Industrial Competitiveness and American National Security," in Wayne Sandholtz *et al.* (eds.), *The Highest Stakes: The Economic Foundations of the Next Security System*, New York, Oxford University Press, 1992, p. 9.
18. Denis Fred Simon, "Techno-Security in an Age of Globalization," in Denis F. Simon (ed.), *Techno-Security in an Age of Globalizatio*n, New York, M.E. Sharpe, 1997, pp. 3-21.
19. Kenneth N. Waltz, *Theory of International Politics*, Reading (Mass.), Addison-Wesley, 1979, p. 126.
20. On the economic and domestic politics dimension of the chip migration in the Taiwan-China context, see, for example, Michael S. Chase *et al.*, *Shanghaied? The Economic and Political Implications of the Flow of Information Technology and Investment across the Taiwan Straits*, Santa Monica, Rand Corporation, 2004; T. J. Cheng, "China-Taiwan Economic Linkage: Between Insulation and Superconductivity," in Nancy Bernkopf Tucker (ed.), *Dangerous Straits: The U.S.-Taiwan-China Crisis*, New York, Columbia University Press, 2005, pp. 93-130; Thomas R. Howell *et al.*, *China's Emerging Semiconductor Industry*, San Jose, Semiconductor Industry Association and Dewey Ballantine LLP, 2003, pp. 67-76; Chyan Yang and Shiu-wan Hung, "Taiwan's Dilemma across the Strait," *Asian Survey*, vol. 43, n°4, 2003, pp. 681-696; Barry Naughton, "The Information Technology Industry and Economic Integrations Between China and Taiwan," in Francoise Mengin (ed.), *Cyber China: Reshaping National Identities in the Age of Information*, New York, Palgrave Macmillan, 2004, pp. 155-84.
21. On the security aspect of the industry dimension in the US-PRC-Taiwan or Sino-US contexts, see, for example, General Accounting Office, *Export Controls: Rapid Advances in China's Semiconductor Industry Underscore Need for Fundamental U.S. Policy Review*, Washington, D.C., General Accounting Office, 2002; Joseph I. Lieberman, *White Paper: National Security Aspects of the Global Migration of the U.S. Semiconductor Industry*, June 2003, available at: http://www.senate.gov/~lieberman/semi.pdf, accessed on 15 November 2003; Michael Klaus, "Red Chips: Implications of the Semiconductor Industry's Relocation to China," *Asian Affairs: An American Review*, vol. 29, n° 4, 2003, pp.237-253; Defense Science Board Task Force, *High Performance Microchip Supply*, Washington, D.C., Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, February 2005.

As far as methodology is concerned, the research adopts a qualitative case study approach supplemented by related quantitative data. More than 130 interviews with industry leaders, officials, and experts were conducted chiefly in the US and Asia, while secondary English-language and Chinese-language materials were gathered in the US, Asia, and Europe. In particular, the study involved interviews with top management executives from seven of the top eight chip makers in Taiwan and China according to a revenue ranking in 2004. While accepting the assumption of "partial and imperfect knowability," [22] this paper succinctly summarises preliminary empirical findings based on a triangulation of interviews and secondary data analysed so far.

Migration of the Taiwanese semiconductor industry to China

As the semiconductor industry becomes increasingly global, China has emerged as its new centre of gravity as IDMs, [23] IC design houses, foundries, [24] and assembly and testing companies in North America, Europe, and Asia shift part of their production operations to China. [25] George Scalise, President of the Semiconductor Industry Association (SIA), dubbed the trend "a new outsourcing model" that is different from the outsourcing activities of the sector over the past decades and may become a significant factor in the development of Chinese chip capabilities in due course. In Scalise's own words,

> *"What is very different about the China outsourcing is that it is not just assembly and testing... It has migrated to the front end and towards the leading edge very quickly. [Consequently], they are now rapidly moving toward a design capability, which would then call for perhaps a fully integrated semiconductor capability."* [26]

Scope, speed and cause of the migration

Contributing in part to the semiconductor shift to China is the wholesale westward movement of the Taiwanese chip industry. The scope of the industry movement through relocation, technology transfer, investment, and human resource flow is extensive, and challenges some of the previous beliefs that Taiwanese input into China's IC industry is largely confined to the IC manufacturing sub-sector. [27] 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 (see Fig. 1).

As far as upstream IC design is concerned, field research data indicate that some of Taiwan's top IC design houses have obtained Taiwanese government permission to establish offices in China to provide "technical support" to local customers. However, some of these China-based operations have illegally engaged in R&D work outsourced from company headquarters in Taiwan. [28]

First-hand research also shows that IC manufacturing is by far the most important sub-sector in China's semiconductor industry and the one in which Taiwan has its strongest foothold. "Calibre, capital, and technology from Taiwan have made tremendous contributions to IC manufacturing [in China]," observed Taiwanese-born Nasa Tsai (*Tsai Nan-hsiung*), former President of Grace Semiconductor Manufacturing Corporation (GSMC, *Hongli*), and currently president of Sinomos Semiconductor (*Zhongwei*). Both GSMC and Sinomos are China-based foundries associated with Taiwan. [29]

Interviews with executives from seven of the top eight chip makers in Taiwan and China have provided additional evidence in support of Tsai's observation. [30] For instance, China's flagship foundry SMIC is led by Taiwanese-American Richard Chang and houses some 650 employees

22. Gary King *et al.*, *Designing Social Inquiry: Scientific Inference in Qualitative Research*, Princeton, Princeton University Press, 1994, pp. 6-7.
23. IDM refers to integrated device manufacturer, a company that performs every step of the chip-making process, including design, manufacture, testing, and packaging.
24. A foundry refers to a semiconductor manufacturer that makes chips for third parties.
25. Marco Mora, SMIC Chief Operating Officer, dubbed the trend "geographical shifts" at SEMICON China, 15 March 2005, Shanghai, China. A recent illustration is Intel's announcement in late March 2007 that it would build a 12-inch wafer fab in China using 90nm process technology to produce chipsets for its major microprocessor business. See, for example, "Intel to Build 300mm Wafer Fabrication Facility in China: Fab 68 in Dalian is $2.5 Billion Investment," 26 March 2007, Press Release, available at http://www.intel.com/pressroom/archive/releases/20070326corp.htm, accessed 26 March 2007; Electronic Engineering Times (Internet Edition), 26 March 2007.
26. Interview, 8 December 2004, San Jose, California.
27. T. Howell *et al.*, *China's Emerging Semiconductor Industry*, *op. cit.*, pp. 67-76.
28. Interview with a former Taiwanese IC design house president involved in leading the company's operations in China, 20 July 2005, Taipei, Taiwan; interview with a Taiwanese IC design house chief, 9 September 2005, Beijing, China; interview with a Taiwanese IC design house vice president, 15 July 2005, Hsinchu, Taiwan.
29. Interviews, 14 September 2005, Ningbo, China.
30. The 2004 ranking is based on the IC Insight data, as cited by *Los Angeles Times* (Internet Edition), 3 January 2005. In 2004, top eight chip makers in Taiwan and China included TSMC, UMC, SMIC, Huahong-NEC, ASMC, CSMC, He Jian, and GSMC. The ranking changed subsequently with He Jian outperforming many of its challengers on mainland Chinese soil. According to iSuppli in June 2005, SMIC retained its No.1 position in China's foundry market in 2004 with 42 percent of the Chinese market share, followed by Huahong NEC, He Jian, ASMC, GSMC, and CSMC. In 2005, IC Insights data ranked the companies as follows: SMIC, Huahong NEC, He Jian, ASMC, Shougang NEC, GSMC, and CSMC. See *Purchasing Magazine* (Internet Edition), 18 May 2006.

The SMIC factory in Shanghai
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from Taiwan. The firm's Taiwan-born staff account for 59 percent of its total workforce employed from outside China. (31) Insiders in China's chip industry pinpointed what they saw as the pivotal role that Chang has played as a latecomer 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," commented a mainland Chinese veteran engineer with more than 35-year experiences in the country's chip industry. (32) Company reports show that SMIC's sales revenue figure reached US$1.16 billion in 2005, accounting for 7 percent of the global foundry market.

In addition, Taiwan Semiconductor Manufacturing Company Ltd. (TSMC, *Taijidian*), headquartered in Hsinchu, Taiwan, has established a wholly-owned subsidiary in Shanghai with approval from the Taiwan government. As the world's No.1 pure play foundry, TSMC's sales revenues reached US$8.22 billion in 2005, accounting for nearly half of the global foundry market. In 2002, the firm became the first chip foundry to enter the ranks of the top 10 IC companies in terms of worldwide sales, claiming the ninth spot.

In addition, TSMC's archrival United Microelectronics Corporation (UMC, *Liandian*), also headquartered in Taiwan, has "made use of the grey area" in existing government rules to help establish He Jian in Suzhou, China. (33) As the world's No.2 pure play foundry, UMC reported sales revenues totalling US$2.82 billion in 2005, and claimed a 19 percent share of the global foundry market.

Similarly, GSMC, a pure-play foundry in Shanghai, is also strongly influenced by the Taiwanese. (34) GSMC currently houses some 100 Taiwanese employees, and Taiwan-born staff account for two-thirds of the company's workforce employed from outside mainland China. (35) In December 2006, Taiwan's government approved plans for 8-inch wafer fab investment in China by the memory chip makers Powerchip Semiconductor (*Lijin*) and Promos Technology (*Maode*). (36) Finally, some second-tier China-based chipmakers focusing on 6-inch wafer foundries, such as CSMC (*Huarunshanghua*) and Sinomos Semiconductor, are also run by managers recruited from Taiwan. (37)

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. (38)

So what has triggered the westward migration of Taiwan's chip industry? Perceived market, manpower, and policy incentives in China appear to be key factors. For example, a critical player involved in UMC's establishment of He Jian (Hejian) said, "We came chiefly because of market and [manpower] calibre." (39) The market factor is linked to China's insatiable demand for semiconductors due to its dominance in electronic system production and its fast-growing end-use markets. According to IC Insight Inc., China's semiconductor market reached US$40.8 billion in terms of overall consumption in 2005, making it the world's largest IC market for the first time, and it is expected to reach US$124 billion in 2010. (40) F.C. Tseng (Tseng Fan-cheng), Vice Chairman of TSMC, also pointed to market considerations as the key driver behind TSMC's establishment of a subsidiary in China: "[We went there] in order to get our market share in mainland China's domestic market." (41) Likewise, many corporate executives in the IC design sub-sector identified perceived market opportunities in China as a driving force in their move to China. (42)

The availability of local talent in China serves as another magnet attracting Taiwan's IC sector westward. In the UMC-He Jian case, He Jian's top executive argued that anticipated shortages of industry-calibre manpower at home

31. According to the author's calculation based on data offered by SMIC in September 2005, 86 percent of the firm's 8,400 employees are from mainland China, whereas the remaining 14 percent are from outside of the country. Among 1,100 employed from outside China, 650 are from Taiwan and 200-250 are from the United States.
32. Interview with a Chinese industry player associated with one of China's earliest state-run semiconductor companies, 17 September 2005, Shanghai, China.
33. Interview with a top executive, He Jian, 21 September 2005, Suzhou, China.
34. GSMC was jointly founded by Winston Wang, son of Taiwan's top tycoon Wang Yung-ching, and Jiang Mianheng, son of former Chinese President Jiang Zemin and Vice-President of the Chinese Academy of Sciences (CAS).
35. Interview with the firm's chairman Zou Shichang, 27 September 2005, Shanghai, China.
36. Press release, Investment Commission, Ministry of Economic Affairs, Taiwan, 27 December 2006. Available at http://www.moeaic.gov.tw, accessed 15 January 2007.
37. Interview with CSMC chairman, 25 September 2005, Shanghai, China; interviews with Sinomos chairman and president, 14 September 2005, Ningbo, China.
38. Interviews with industry players, September 2005, Shanghai, Suzhou, and Ningbo, China.
39. Interview, 21 September 2005, Suzhou, China.
40. *Purchasing Magazine* (Internet Edition), 18 May 2006.
41. Interview, 29 June 2005, Hsinchu, Taiwan.
42. See, for instance, interview with a Taiwanese IC design house chief, 9 September 2005, Beijing, China.

strengthened UMC's resolve to establish He Jian. [43] Talent pool considerations have also pushed Taiwan IC design houses to cross the Straits, especially in the design sub-sector. As system-on-a-chip (SOC) becomes the dominant trend, IC design technological complexity is increasing, [44] and this, in turn, requires a growing number of hardware and software engineers for the increasingly challenging task of IC design. Extending operations in China beyond technical support hubs enables companies to absorb local talent into entry-level or software work in overall IC design R&D packages as a means of sharing workload with the firm's headquarters in Taiwan. [45]

Secondary to Taiwan IC firms' considerations over migrating to China are policy incentives that the Chinese government has offered to outside players eyeing a foothold in China. These incentives include preferential tax treatment and infrastructure arrangements such as land, water, and electricity supply.

Means of violating Taiwan's state controls

Certain patterns of behaviour have assisted some Taiwanese chip firms and individuals in evading government regulations at home in order to move to China:

(1) The guise 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 funnelling funds to China-based IC design houses. [46] Current regulations in Taiwan, however, forbid such moves. [47]

(2) IC design R&D work operating behind the veneer of approved "technical support" functions in China-based branch offices: The China branches of some Taiwanese IC design houses have hired local engineers to take part in aspects of IC design R&D, such as software-related work, while the company's core-technology R&D remains headquartered in Taiwan. [48] As mentioned earlier, "technical support" work by Taiwanese IC design house offices in China is permitted by the Taiwanese government, whereas IC design R&D work is not.

(3) US citizenship helps: Some Taiwanese individuals who are nationals of both Taiwan and the United States have emphasised their identities as US citizens while working in China's IC industry. Such moves reflect attempts to evade Taiwanese regulations that might apply to them as Taiwanese nationals should their involvement in China's chip sector be considered illegal by the government in Taiwan. [49]

(4) Clandestine ownership change: Fieldwork research discovered that in at least one instance, a Taiwanese chip firm launched operations in China after the government in Taiwan gave the green light to its application, then covertly took over ownership of a China-based company carrying out operations for which it had not yet received permission. It was only after more than a year that the Taiwanese firm applied for permission from the Taiwanese government to acquire the Chinese company. [50]

(5) Moving into higher-end production without government approval: Some Taiwanese chip firms illegally move into higher-end production at a later stage of their operations in China, even though the Taiwanese government has confined its permission to investment in lower-end production.

(6) Firms initially set up in China in contravention of 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 0.18 micron and investment in 12-inch wafer fabs in China. However, some foundries in China that were established with Taiwanese input, especially in terms of managerial and engineering talent and capital, continue to circumvent Taiwanese regulations to develop beyond official restrictions. At least two of them have long been using process technology for feature sizes smaller than 0.18 micron. One, in particular, offers 0.35 micron to 90nm IC manufacturing services to its customers and

43. Interview, 21 September 2005, Suzhou, China.
44. 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." See Greg Linden and Deepak Somaya, "Systems-on-a-Chip Integration in the Semiconductor Industry: Industry Structure and Firm Strategies," *Industrial and Corporate Change*, vol. 12, n° 3, 2000, pp. 545-576.
45. Interview with a former Taiwanese IC design house president involved in leading the company operations in China, 20 July 2005, Taipei, Taiwan; interview with a Taiwanese IC design house president, 27 October 2005, Taipei, Taiwan.
46. Interviews with industry players, August, September, and December 2005, China and the United Kingdom.
47. Interview with Huang Chintan, Executive Secretary, Investment Commission, Ministry of Economic Affairs, 18 August 2005, Taipei, Taiwan.
48. Interview with a Taiwanese IC design house vice president, 15 July 2005, Hsinchu, Taiwan.
49. Richard Chang's application to relinquish his Taiwanese citizenship while keeping his US citizenship is a case in point. Another instance is that two professionals from Taiwan currently heading one of China's chip foundries 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. Interviews with industry players, September 2005, Shanghai, China.
50. Interviews with various industry players, September 2005, Shanghai, China; related Taiwanese government press release, 27 December 2006.

has already operated one 12-inch wafer fab. [51] These moves clearly go beyond the Taiwanese government's artificially imposed ceiling. [52]

To sum up, across the chip industry we can see Taiwanese chip firms and individuals turning a blind eye to existing regulations at home that are designed to control semiconductor-related investment and technology transfer to China. In this respect, government rules in Taiwan are mere attempts to "control the uncontrollable" in terms of curtailing the chip sector's westward flight driven by a combination of economic factors. Although Taiwan is far from being the only external player that has facilitated the Chinese chip industry's catch-up process, first-hand research shows that Taiwanese input has been pivotal. "Through various forms of 'internationalisation,' calibre and capital from Taiwan have entered mainland China and played important roles. GSMC, SMIC, TSMC and He Jian, for example, cannot shake off their links to Taiwan... [Taiwan's President] Chen Shui-bian (*Chen Shui-bian*) is unable to control the trend. Taiwan has already exerted its impact here," said a heavyweight player in the Chinese chip industry. [53] The question that remains is to what extent these profit-driven activities across the Straits might trigger security risks for the countries involved.

Security implications of the chip industry migration

The migration of the Taiwanese chip sector to China has arguably triggered multiple layers of security ramifications for Taiwan and the United States involving economic, technological, and defence security. The analysis here will chiefly focus on four inter-linked aspects of technological and defence security challenges Taiwan and the US face in the wake of China's growing chip manufacturing and design capabilities resulting from external input from the outside, including Taiwan's. These challenges include: (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 China's institutional reforms and its perception of the chip's importance to its industrial base, military modernisation and modern electronic warfare; (4) risks reinforced by the Taiwan factor.

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" [54] in modern weapons, communications, navigation, space, and battle management systems, all of which 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 the very good industrial bases, part of which depend upon solid IC industry supply chains," observed a veteran industry player. "Following China's opening-up policy, the nation's overall industrial base can become a critical driving force that helps enhance Chinese defence and aerospace technologies if its IC industry, along with other system manufacturing industry bases, develop quite well." [55]

The continued development of China's chip industrial base is undoubtedly accelerated by foreign input 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, organisational, and institutional challenges in establishing a fully-fledged chip industrial base. [56] Significant contributions by players from outside, including Taiwan, are apparent. 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) shuttle service, these foundries offer subsidies to local customers to assist them with their prototyping efforts by sharing exorbitantly expensive masks. [57] These customers include local design houses and research institutes, such as the influential Chinese Academy of Sciences (CAS). Foundries in China – which is where Taiwanese input is most apparent – contribute to the growth and development of China's chip industrial base by elevating IC design development and feeding orders to back-end

51. *Electronic Engineering Times* (Internet Edition), 12 May 2006; *Economic Daily* (Internet Edition), 7 September 2006; various company websites.
52. One firm in question continuously argues that it should not be under the reign of Taiwanese regulations because it is a MNC registered outside of Taiwan and based in China, and the other has long operated in defiance of Taipei's official rules. The former company's efforts to dilute its Taiwan connection seem futile, however, as numerous interviewees in the field described the firm as a stark example of Taiwanese contributions to the Chinese chip industrial catch-up.
53. Interview, 30 August 2005, Beijing, China.
54. Interview with Michael R. Polcari, President & CEO of International SEMATECH, 7 January 2005, Austin, Texas.
55. Interview, 9 September 2005, Beijing, China.
56. Market forecasters disagree about the overall outlook of the Chinese chip industry. A Chinese market analyst, for instance, predicts that half of China's fab hopefuls will fail because of the lack of partnerships and manufacturing expertise. See *Electronic Engineering Times* (Internet Edition), 10 July 2006.
57. "Mask" refers to the device used to shape desired geometries on the surface of the wafer.

packaging and testing operations.[58] Thus, initial external input, as mentioned earlier, unquestionably serves as a long-term catalyst for the creation of 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, as resources in a strong industrial base invariably spill over into the military through technological and talent exchanges between an economy's civilian and defence sectors.

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 can also help design and manufacture critical chip hardware tailored to the PLA's needs. The supply of both advanced commodity ICs and application-specific integrated circuits (ASICs) at home, in turn, can overcome the long-standing risks the PLA has faced from unreliable foreign supplies of critical chip components.[59] It also helps China mitigate outside influences intent on slowing advances in the PLA's capabilities, in particular the US-led export controls designed to curb inflows of militarily-sensitive semiconductor items, equipment, and materials to China.

Technology-related risk

Aside from industrial base security concerns, the cross-Strait chip industry migration 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* have argued, most technology is dual-use or multi-use in nature,[60] and semiconductors are no exception. For instance, chips that make precise missile guidance possible can also appear in mobile phones and automobiles. By the same token, the underlying semiconductor process technology for manufacturing IC components for consumer electronics is fundamentally the same as that for military electronics.[61] So if a nation's chip industry attains cutting-edge capabilities to fabricate chips chiefly for non-military end-users (such as cell phones, PCs, and automobiles), a related process technology can arguably be used to make chips for military applications, depending on the design. China's chip industry is in the process of catching up to feed civilian end-users, domestic and international alike, but the cutting-edge technology accumulated for these purposes can potentially serve the needs of the Chinese military.[62]

The technological development trajectory switch from "spin-off" to "spin-on" adds further complexity to the picture.[63] Many technologies critical to military power have been gradually discovered in the civilian rather than military markets. Partly in response to the increasing commercial availability of high-performance ICs and partly for monetary reasons, the Perry Initiative of 1994 has changed the US defence acquisition policy to an emphasis on buying commercial-off-the-shelf (COTS) components for new system designs. As a result, the commercial market where high-end chip components are available has become a supply dump for the US defence establishment.[64] The US policy change has spilled over to other countries such as Taiwan[65] and China, as a result of which 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 percent per year," although COTS are not recommended for radiation military and aerospace systems, where such insertion can jeopardise the systems in question.[66] It is highly likely that the defence sectors in other countries, including China, can and will continue to seek high-performance IC supplies from the commercial market for monetary and technical reasons whenever possible. If China's chip industry becomes a viable

58. Although the foundry-fabless development model seems to dominate the current chip industrial landscape in China, partially copying the success story in Taiwan, some favor the IDM model instead.
59. Several technology journals in China have mentioned the headache of foreign supply of electronic components faced by the nation's defence and aerospace sectors.
60. Lewis M. Branscomb *et al.*, *Beyond Spinoff: Military and Commercial Technologies in a Changing World*, Boston, Harvard Business School Press, 1992, p. 4.
61. Interview with Michael R. Polcari, President & CEO of International SEMATECH, 7 January 2005, Austin, Texas.
62. The U.S.-China Security Review Commission, "Technology Transfers and Military Acquisition Policy," in *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* (Internet Edition), Washington D.C., US Government Printing Office, July 2002. Available at http://www.uscc.gov/researchpapers/2000_2003/reports/ch10_02.htm, accessed 4 May 2004.
63. Military systems use many IC components that must incorporate certain technologies for which there is no commercial demand. These include technologies required for radiation hardening, high-power microwave, and millimeter-wave circuits and special sensor requirements. See Defense Science Board Task Force, *High Performance Microchip Supply*, *op. cit.*, p. 24, quoting *Critical Assessment of Technologies*, DOD Advisory Group on Electron Devices, 2002.
64. William J. Perry, *Specifications and Standards- A New Way of Doing Business*, Memo, Department of Defense, 24 June 1994. The Perry Initiative advocated greater reliance on COTS items from commercial marketplace and greater use of performance and commercial specifications and standards. Subsequent benefits from the US defense acquisition policy change have followed, including marked improvement in cost reduction, performance, and development times of microelectronic elements of defence systems.
65. Interview with Abe C. Lin, Director General, Integrated Assessment Office, Ministry of National Defense, 27 June 2005, Taipei, Taiwan.
66. Michael C. Maher, "Can COTS Products Be Used in Radiation Environments?" *COTS Journal* (Internet Edition), December 2003, available at http://www.cotsjournal online.com/home/printthis.php?id=100089, accessed 12 August 2005.

designer and producer of high-end chips for commercial use that possess superior functions to those produced by the defence sector, the civilian side of the industry can surely act as a COTS supply pool for the military.

However, fieldwork data indicate that at least two factors may affect whether China-based IC companies sell chips for Chinese military and aerospace end-use. The first factor involves the extent of incentives that the relatively small military market can offer, while the second element concerns the ownership of the chip firm in question.

As for the first factor, the military market has steadily accounted for less than 5 percent of the global chip end-use market over the past few decades, despite its initial dominance in the global chip market, and the small quantities of chips ordered by the military, accompanied by stringent procurement process requirements, have arguably led to the departure of many chip companies (e.g., Motorola) from the military market. If these developments in the global chip market hold true in China, it remains to be seen whether Chinese military and aerospace end-users will be able to offer adequate incentives to procure supplies from China-based commercial chip firms.

As for the second factor, China's official electronics industry yearbooks over the past few years have stated that due to national security considerations, procurement of dual-use goods for military end-uses is confined to either wholly state-owned agencies or civilian firms with at least 50 percent government ownership. If this rule still holds today, we can infer that joint ventures with foreign input (such as top managerial and engineering manpower) must have at least 50 percent government ownership in order to qualify for Chinese military procurement contracts.

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, in the United States, the "national security" significance of plasma dry etching equipment has been identified. (67) In addition, Taiwan is identified as one of the primary supplier countries for epitaxial silicon wafers, which are deemed of national security significance because they are "potential starting materials" for certain semiconductor devices. (68) This is why the Pentagon has requested that Taiwan tighten its export controls to ensure that chip equipment re-exported to China will not be used to fabricate chips for military end-use. Interviews in the US and Taiwan have confirmed security concerns shared by both countries in this regard. 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're gonna make them economical and reliable, you need the newer, the new generation equipment." (69)

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 dependence on foreign suppliers for IC components critical to US defence and infrastructure systems is not new, as demonstrated by fierce debates in the United States in the context of the rise of the Japanese semiconductor industry in the late 1980s and the early 1990s. But globalisation of the chip industry has certainly rekindled the security concerns involved.

For the US, the DSB task force study has argued that "trustworthiness and supply assurance for components used in critical military and infrastructure applications are casualties" of the migration of the chip manufacturing capabilities away from the US to potential adversaries. (70) Taiwan has arguably become a part of the globalised defence industrial base that the US defence establishment can exploit for foundry services to the Pentagon and its contractors and subcontractors. (71) As such, the migration of Taiwan's foundry capabilities to China may entail chip supply risks similar to those that raised the DSB's concerns over chip manufacturing capabilities moving away from the US.

In particular, the DSB study has identified several scenarios in which IC parts compromises might make core US defence capabilities vulnerable to enemy attack at critical times. First, potential adversaries can play "dirty tricks" when fabricating critical non-COTS ICs for US demand on their soil. Such tricks could include the insertion of "Trojan horses" or other unauthorised design inclusions in unclassified chips used in military applications. These "contaminated" items could subsequently act as "time bombs" to diminish the function of the chips in critical defence equipment. "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 might be compromised by the shift from a US to foreign IC manufacturer. Third, although the use of

67. General Accounting Office, *Export Controls*, *op. cit.*, p. 39.
68. *Ibid.*, p. 39.
69. Interview, 10 December 2004, San Jose, California.
70. Defense Science Board Task Force, *High Performance Microchip Supply*, *op. cit.*, p. 3.
71. *Ibid.*, p. 24; various interviews with Taiwanese industry players, August and September 2005, Beijing, China and Taipei, Taiwan.

COTS implies less risk insofar as 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."

The above three vulnerability scenarios are compounded by two realities, one technological and the other related to the hierarchical nature of the US defence chip acquisition process. On the technological front, the DSB document has contended that "neither extensive electrical testing nor reverse engineering is capable of reliably detecting compromised microelectronics components." At the acquisition front, the problem stems from the fact that the Pentagon does not acquire components at the IC level; instead, it is often the designers of subsystems who specify individual circuits, and even system primes have limited knowledge of the sources of the chips used in their systems. (72)

To assess the extent to which these IC parts compromise scenarios might damage US technological and defence security, let us turn to relevant fieldwork data analysed so far, which partly substantiate the DSB arguments and partly challenge its claims.

Some defence experts as well as industry players envisage the likelihood of these scenarios against the backdrop of China becoming an increasingly attractive destination for shifting semiconductor capabilities, and at the same time as a perceived strategic rival of the US. Joe Chen (*Chen Yuwu*), 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." (73) A Taiwanese chip design house vice president also did not rule out the possibility of China creating IC parts compromises, citing what he sees as China's antagonism towards the US as the major motivation. (74)

In contrast, an engineer with military IC design experience in the US qualified the DSB argument by evaluating the probability of China inserting backdoor features as an information warfare tactic. In his own word, "It is possible, but it is extremely improbable. It's extremely hard to do. China is still far from being able to do it. The CIA or FBI surely will play such a trick, but the intelligence organisations in China have no energy for such a task. But this doesn't mean that the Chinese won't do it in 20 years." (75)

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

Aside from the IC parts compromise risks described above, dependence on ICs fabricated on foreign soil for US defence applications also exposes the US to other security risks, such as disruption of supply due to war or natural disaster in the supplier country. A major conflict across the Taiwan Straits or a massive tremor in Taiwan, which offers fabrication services for the Pentagon and its contractors, could cause similar disruption of IC supplies to the global chip market. Likewise, Taiwan could be affected by IC supply disruption or blockade if chips needed for its defence and major infrastructure systems eventually depend in part or in whole on fabrication services in China.

As chip capacity shifts to potential adversary countries, the DSB study has also expressed fears that the countries in question could impose a government-led "reverse-ITAR" pressure on the US by denying the US access to critical chip technologies. Just as 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 momentum could refuse to offer foundry services to the US (and arguably to Taiwan) in the future. (76)

Finally, if one assumes that leading-edge R&D tends to follow the migration of manufacturing, the current shift of chip manufacturing capability to potential adversary countries could trigger a similar migration of related R&D. 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 a possible shift to the same destinations by IC designers, could thus threaten US leadership in advanced chip technologies. This, in turn, would affect both commercial and defence product development processes. (77) A former Pentagon official did not rule out this risk scenario. (78)

72. Defense Science Board Task Force, *High Performance Microchip Supply*, *op. cit.*, pp. 4-5, 26.
73. Interview, 9 August 2005, Taipei, Taiwan.
74. Interview, 10 August 2005, Hsinchu, Taiwan.
75. Interview, 7 September 2005.
76. Defense Science Board Task Force, *High Performance Microchip Supply*, *op. cit.*, p. 24.
77. *Ibid.*, p. 25.
78. Interview, 18 January 2005, Washington D.C..

Faced with foreseeable defence concerns, the US government has adopted measures to mitigate these risks and ensure trustworthy sources of critical chip supplies. In particular, the US government has signed a deal to use IBM's "Trusted Foundry" service in Vermont to ensure the supply of leading-edge custom circuits at home. However, some American chip industry and defence sector interviewees argue that it remains unclear whether the Vermont facility alone can address all the major security challenges the US may face with the continued shift of US and Taiwanese chip manufacturing capabilities to China. (79)

Concerns reinforced by Chinese institutional reforms and perceptions

Concerns over industrial base and technology-related security risks are further reinforced by pertinent institutional reforms in China, and China's perception of the chip's importance to its industrial base, military modernisation, and modern electronic warfare.

First of all, State Council directives and General Armaments Department and COSTIND regulations in 2005 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 weapons development and production, and that some would be given to civilian firms. This opened up opportunities for civilian firms to participate in the defence sector, and formally smoothed the channel for transferring resources from the civilian sector to the defence sector. (80)

This institutional change in China, echoing the global trend of enhancing the use of COTS items in defence systems, has arguably reinforced the security concerns outlined above. Unquestionably, the policy change exemplifies the core concept in Deng Xiaoping's "16 Character Policy" that has guided the Chinese military for the past few decades; that is, the need to use civilian profits and resources to maintain the military (*yimin yangjun*), and integrate the military and civilian sectors (*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, and mirrors official attempts to maximise the national technological base upon which China can modernise its military infrastructure by integrating the civilian and the non-civilian sectors. The change also indicates Beijing's recognition of the dual-use and multi-use nature of most technologies, including semiconductor technologies.

None of the interviewed China-based chip firms that were managed or owned by Taiwanese said that they had supplied chips to the Chinese military and aerospace industries. However, the institutional reform may subject China-based firms with Taiwanese input to strong incentives or coercion to sell suitable ICs to the Chinese defence industrial complex, as long as their Taiwan link is not considered an obstacle in the eyes of the Chinese defence establishment. (81)

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

Yu Zhongyu, President of CSIA, said the development of the semiconductor in China is not limited to science and technology considerations: "Not merely to science, the semiconductor industry is also a very important industry to economic development and defence security." (82)

Microelectronics is also on a list of enabling technologies recognised by the Chinese defence industrial complex as critical to the PLA modernisation process. In 1993, for instance, the Chinese space and missile industry formed a research academy dedicated to the development of space-qualified microelectronics. (83) 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 tactic of using backdoor devices in IC components in its war strategies, while advocating similar measures in future warfare. (84)

79. Interviews, December 2004 and February 2005, San Francisco, Washington D.C., and New York.
80. Seth Drewry and William Edgar Edgar, "China Gambles with Private Sector," *Jane's Defense Industry*, 1 November 2005.
81. Some industry interviewees argued that that the Chinese military and aerospace establishment is unlikely to ask Taiwan-related firms to design or fabricate chips for sensitive end-uses due to "national security" considerations. But in at least one instance, a Taiwanese IDM was contacted by a Chinese aerospace institute over the possibility of making radiation-hardened chips used in aerospace environments. Ultimately the deal was not sealed. Interviews, December 2004 and August 2005, USA and China.
82. Interview, 2 September 2005, Beijing, China.
83. Mark A. Stokes, *China's Strategic Modernization: Implications for the United States*, Carlise (PA), US Army War College, 1999, p. 30.
84. Zhang Liying and Guo Jianping, "Ershiyi shijichu shijie keji zouxiang ji woguo keji anquan huanjing yanjiu (World Technology Trends at the Turn of the 21st Century and the Study of Our Nation's Technological Security Environment)," *Keji jinbu yu duice* (*Science & Technology Progress and Policy*), vol. 2, n° 2, 2004, pp. 14-16; Li Jie, "Jisuanji yu xiandai zhanzheng (Computer and Modern Wars)," *Xiandai junshi* (*CONMILIT*), vol.16, n° 12, 1993, pp. 15-18.

Concerns reinforced by the Taiwan factor

The afore-mentioned security ramifications can be further complicated by the Taiwanese chip industry's migration to China because of the following factors:

First, language and cultural proximity, as well as the "great China complex" in the minds of some Taiwanese semiconductor professionals working in China, can facilitate informal and formal know-how transfers and flows between veteran Taiwanese industry players and their Chinese counterparts. In a sector characterised by "learning by doing," language and cultural proximity helps accelerate the speed and efficiency of knowledge transfer. It is exactly in this respect that input from Taiwan plays a distinctive role in helping China catch up in the global IC race with their counterparts from Europe, Japan, and the US. First-hand interviews strongly support this argument. (85) For example, the so-called "great China complex," an aspiration to contribute to the building of a stronger China, is affirmed by Taiwanese American David Wang (*Wang Ning-kuo*), a former senior vice president at Applied Materials who shifted to Shanghai to work as CEO of Huahong (*Huahong*) group in 2005. (86) These intangible factors may join to accelerate the formation of a solid chip industrial base in China in due course.

Secondly, continuous political tensions across the Straits have functioned as a structural constraint that prevents any official Taiwanese presence in China, and make it impossible for Taipei to implement its relevant policies. For instance, how can the Taiwanese government determine that equipment is shipped to China purely for civilian use without on-site inspections? Doubts have been cast on the effectiveness of the US government's on-site inspections of China-based chip firms in an attempt to ensure that no military end-use is serviced by these firms, (87) even though these inspections are legally endorsed by Beijing and Washington. The lack of such an inspection by Taiwanese officials in China makes any unilateral policy in Taipei void. The inability to effectively implement the Taiwanese policy naturally presents a serious pitfall to official regulations, which can be circumvented by private sector actors who wish to avoid exorbitant punitive costs.

Thirdly, the matter is further complicated by political infighting and bureaucratic inefficiency in Taiwan. A draft bill proposed by the government to prevent the flow of Taiwan's sensitive high technologies and creative talent to mainland China has been buried in legislative committee proceedings for numerous parliamentary sessions. The US defence establishment and academics failed to anticipate this domestic political dimension, however, (88) with some predicting that the bill would sail through the legislature with ease. (89) "Our current difficulty is that the bill is yet to sail through the legislature," admitted Wu Maw-kuen (*Wu Maw-kuen*), the then Minister of Taiwan's National Science Council. (90) At a time when Washington is proposing new policies to enhance civilian trade with China while preventing sensitive exports to the Chinese military amid protest from Beijing, Taiwan has yet to pass its own much less comprehensive bill. (91) As a result, Taiwan could become the weakest link in any attempt to curb transfers of advanced dual-use chip technologies with potential military significance and much-needed investment to China.

Fourthly, although the Taiwanese chip sector largely designs and produces chips for civilian end-use, Taiwan's strong IC design and manufacturing capabilities have the potential to cater to the needs of the defence sector. Fieldwork research has discovered that some Taiwan firms have offered foundry services to the Pentagon, its contractors, and subcontractors, as well as Taiwan's defence establishment, although the business accounts for only a small part of the companies' revenues. Taiwan's foundry and design services could just as easily be made available to defence sectors elsewhere, including China. (92)

In sum, a semiconductor industry is a building block for a strong defence, although other factors such as system integration and software capability are equally, if not more, important to a nation's defence capability enhancement.

85. Interview with a chip design house R&D vice president with experiences operating the firm's office in China, 19 August 2005, Hsinchu, Taiwan; interview with a Taiwanese IDM branch office chief, 24 March 2005, Shanghai, China.
86. Interview, 24 August 2005, Beijing, China.
87. Michael D. Klaus, "Dual-Use Free Trade Agreements: The Contemporary Alternative to High-Tech Export Controls," *op. cit.*, p. 114.
88. Defense Science Board Task Force, *High Performance Microchip Supply*, *op. cit.*, p. 44; M. Chase *et al.*, *Shanghaied ?*, *op. cit.*, p. xvii.
89. *Liberty Times* (Internet Edition), 29 August 2002; Commercial Daily (Internet Edition), 17 March 2006.
90. Interview, 24 June 2005. Wu stepped down as the Science minister in January 2006.
91. In July 2006, the US Department of Commerce proposed to revise the Export Administration Regulations (EAR) for exports and re-exports of dual-use items to China. Proposed rules were published in *Federal Register*, vol. 71, n° 129, 6 July 2006, pp. 38313-38321. For related protests from Beijing's China Arms Control and Disarmament Association, see *Xinhua Economic News* (Internet Edition), 30 August 2006. Meanwhile, Taiwan's draft bill does not even contain a significant element in existing EAR, namely, the "deemed export" control mechanism. "Deemed exports" refer to transfers of controlled technology to foreign nationals within the US.
92. In one instance, a Taiwanese foundry was found to be serving a dubious local IC design house in China. The firm is a spin-off of a state-run research institute that has a track record in supplying analog ICs for gadgets inserted in China's Hangtien project ShengZhou No.5. However, the exact end-use of the chips fabricated by the Taiwanese foundry remains unclear.

The migration of the Taiwanese chip industry to China, like the shift of the US chip manufacturing base from the US, 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 that have uneasy political and defence relations with China, but which are driven by economic forces to help China catch up in the chip race, naturally face enormous security risks. Taiwan and the US are the countries most affected by the latest dynamic in the global chip industry, which has shifted the spotlight to China, the ambitious latecomer.

Conclusion

To sum up, the empirical case study shows that in an age of globalisation, economic forces can be so compelling as to limit or thwart any attempts by state actors to curb cross-border economic movements led by firms or individuals, even in the name of security. The dilemma faced by the Taiwanese state facing a powerful chip industry's resolve to move into China seems to support the "state in retreat" school of thought in globalisation-related literature. The challenges faced by the US government tell a similar story, if to a lesser extent.

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 globalisation. The chip industry migration across the Straits entails potential security risks for the countries involved, but we may be blind to the full complexity of these risks without a sectoral-based multidisciplinary analysis. Beyond war, global security encompasses other important areas – such as technological aspects of security and economically driven security challenges – in which substantial empirical research is needed to advance our understanding of the volatile contemporary world. For that reason, it may be time to embrace a widener's approach to the study of security. •

Glossary

Zhongxin	中芯
Chang Ju-ching	張汝京
Tsai Nan-Hsiung	蔡南雄
Hongli	宏力
Zhongwei	中緯
Taijidian	台積電
Liandian	聯電
Lijin	力晶
Maode	茂德
Huarun shanghua	華潤上華
Hejian	和艦
Tseng Fan-cheng	曾繁城
Chen Shuibian	陳水扁
Chen Yu-wu	陳友武
Wang Ning-kuo	王寧國
Huahong	華虹
Wu Maw-kuen	吳茂昆