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Making Middle-Power Alignment Work: Reinforcing Taiwan-Vietnam Collaboration in the Semiconductor Industry

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Abstract

Through their joint initiatives, emerging middle powers are taking on a bigger role in the Indo-Pacific. But current scholarship on middle powers mainly focuses on countries with well-established reputations, such as Australia, Canada, South Korea, and Japan. Taiwan and Vietnam are two prime examples of emerging middle powers whose role and contributions have been under-examined. The authors contend that, against the backdrop of US-China technology competition, Taiwan and Vietnam should enhance collaboration in the semiconductor industry in an effort to forge closer ties and navigate geopolitical shoals and reefs, leading to the development of a more resilient semiconductor value chain. This paper discusses Taiwan's crucial role as a potent player in the global semiconductor business in addition to presenting Vietnam's aspirations to become Southeast Asia's hub

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for semiconductor manufacture. By working on this understudied area, the authors wish to offer suggestions on how the two partners could bolster ties through workable plans to reinforce technology collaboration.

Keywords: *emerging middle powers, semiconductor, Taiwan, Vietnam, Indo-Pacific.*

1. Introduction

Taiwan and Vietnam have incrementally come to be seen as middle-powers strenuously seeking a proactive role in the Indo-Pacific region. According to The Lowy Institute's 2023 *Asia Power Index* (The Lowy Institute, 2023), both Taiwan and Vietnam have been recognized as middle powers in Asia. While Taiwan "has embraced niche diplomacy—a sort of diplomacy conducted in selected areas falling within the scope of interest and capacity of middle powers to forge their manoeuvrability and flexibility" (Sang, 2022), Vietnam has been working tirelessly towards bolstering multilateralism and seeking pro-activism in niche diplomacy, particularly in the realms of "climate change, plastic pollution, water security, gender equality and peacebuilding efforts at various international fora" (Do, 2022).

Taiwan and Vietnam's growing importance in international affairs has also been attributed to the strategic values they embrace. Taiwan sits at the critical node of the first island chain and holds strategic implications for upholding democracy in East Asia where Chinese aggression has become more blatant (Sacks, 2023). Should China be able to annex Taiwan or bring Taiwan under its control, the great power could possess leverage to undermine regional stability and threaten the balance of power in the Indo-Pacific. As for Vietnam, it is acting as a bulwark and a "strategic card" that can alter the regional balance of power, and its "ascendant geostrategic importance" is becoming more prominent as the US-China strategic competition intensifies (Dung & Ho, 2022).

Despite the fact that Vietnam does not officially recognize Taiwan, the Southeast Asian country has carefully nurtured ties with the East Asian partner, particularly in economic and cultural aspects. In 2022, Vietnam-Taiwan trade achieved a new ride, with a total two-way import and export turnover of approximately $28 billion, and Vietnam is Taiwan's 10th largest trading partner (Communist Party of Vietnam Online Newspaper, 2023). In

terms of geostrategic values, the two partners have been grappling with the "geographical tyranny" and share strategic ideals, such as their asymmetric relationship with China, a pragmatic strategy for navigating great-power competition, and strategic flexibility to deal with regional challenges. In the midst of the Sino-US economic rivalry, Taiwan and Vietnam are considered as trade dispute winners and attractive sites for business investment (Sang, 2021).

Under the New Southbound Policy launched in 2016, the Tsai Ing-wen administration has committed to strengthen Taiwan's ties with Southeast Asian countries, with Vietnam serving as the focal point (Chung, 2020). As emerging middle powers in Asia, Vietnam and Taiwan see eye to eye on the need of upholding international law and multilateralism while working for a stable and prosperous region free of coercion and intimidation. Among the areas of cooperation between Taiwan and Vietnam, the semiconductor field emerges as a promising playground where both parties can strategically support each other in a win-win situation.

Semiconductors are currently an indispensable strategic asset in the modern global economy (Council of The European Union, 2022), much like petroleum was during the Cold War era. These minuscule yet indispensable constituents constitute the fundamental framework of electronic devices, propelling advancements across various sectors, such as communication, computing, healthcare, military infrastructure, transportation, clean energy and an array of other practical uses (Semiconductor Industry Association, 2023). Their centrality to the digital economy is unequivocal. The market valuations of semiconductor enterprises are already worth more than $4 trillion (The Economist, 2021), which indicates a dramatic increase in demand for chips. Along with the dramatic rise in telecommuting and housebound consumers, this demand boom has been much more pronounced since the COVID-19 pandemic. It is believed that the rise of the automotive sector and the deployment of 5G networks would further amplify this demand (Holmström, Kenney & Seppälä, 2021).

The semiconductor value chain is structured into three essential phases. Initially, the design stage serves as the starting point for chip production, delineating requirements, structuring the chip, and validating its design on a testing platform. This phase significantly contributes to semiconductor value and necessitates an allocation of approximately 10 to 15 per cent of physical capital expenditure. Subsequently, the fabrication, foundry, or manufacturing

phase involves imprinting the integrated circuit onto a silicon wafer, constituting a quarter of the added value and accounting for nearly two-thirds of the physical capital expenditure in the semiconductor industry. Lastly, the assembly, test, and packaging phase encompass the segmentation of wafers into individual chips, their encapsulation, and subsequent testing. Although this phase requires a lesser degree of specialized skills and knowledge compared to preceding stages, it contributes approximately 5 per cent to the semiconductor added value while representing 10-15 per cent of the physical capital expenditure (Haramboure, Lalanne, Schwellnus & Guilhoto, 2023).

The intricate process of semiconductor chip production demands extensive knowledge and relies heavily on the expertise of proficient suppliers (Holmström, Kenney & Seppälä, 2021). Consequently, recent years have witnessed a notable trend towards vertical disintegration within the industry, with specific firms specializing in distinct stages of the supply chain (Mönch, Chien, Dauzère-Pérès, Ehm & Fowler, 2018). With the rapid growth of the semiconductor industry, semiconductor manufacturing and design companies are well-positioned to make significant contributions to the global economy (Ondrej Burkacky, 2022). This marks the beginning of a new era in which nations will need to work together to take advantage of opportunities and weather challenges. As for Taiwan and Vietnam, Taiwan has a well-established advantage in manufacturing and has recently made progress in the design phase of the semiconductor value chain. On the other hand, Vietnam has been steadily emerging as a hub for chip assembly, packaging, and testing.

This study offers valuable insights into the symbiotic collaboration between Taiwan and Vietnam in the semiconductor sector, serving as a means for these two mid-sized powers to enhance their influence in the regional sphere. The paper examines Taiwan's significant role as a key participant in the regional semiconductor market and Vietnam's capacity to emerge as a semiconductor manufacturing hub in Southeast Asia. Ultimately, suggestions are devised for both parties to enhance their mutually beneficial relationship in the semiconductor sector.

2. Taiwan: A Leading Player in the Global Semiconductor Industry

Globally renowned, Taiwan has swiftly garnered widespread recognition due to its remarkably prosperous semiconductor industry, which has been the key driver of the nation's economic trajectory since the 1980s (Chang,

Shih & Hsu, 1994). By the year 2022, the aggregate value of Taiwan's exports within the integrated circuit domain amassed an impressive volume of $184 billion, constituting approximately 25 per cent of the country's Gross Domestic Product (Pang, 2023). Keeping Taiwan's strategic importance and international allies intact in the face of worsening ties with China is seen as critically dependent on the island's semiconductor sector. The contemporary significance of semiconductors within the worldwide economic landscape has bestowed upon Taiwan's semiconductor industry the epithet of the "silicon shield", defending the self-ruled island against security vulnerabilities and external hazards. So far, Taiwan has achieved notable accomplishments across all three segments of the semiconductor value chain.

In the design segment, Taiwanese companies account for six to seven per cent of the global market share in the period 2005 - 2020 (Semiconductor Industry Association, 2022). As Taiwan's importance in the international semiconductor industry grows and the industry dynamics shift, catalysed by the ongoing profound restructure of the global supply chain and the global roll-out of commercial 5G services (Department of Information Services, 2022), Taiwanese semiconductor enterprises face greater pressure to boost substantial investments in research and development (R&D) to elevate the domestic industry's standing in the highest segment of the value chain, going beyond historical practices merely centred around accepting contract production orders (Chen & Jan, 2005).

Initially, government support entities, including the Institute of Industrial and Technical Research (ITRI) and the National Applied Research Laboratory (NARL), have exerted a notable influence in cultivating the scientific foundation and fostering innovation within Taiwan. Their efforts encompass the provision of support for R&D endeavours within the private sector and the exploration of emergent technologies (Rasiah, Shahrivar & Yap, 2016). Central to this context, the inception of the Institute of Industrial and Technical Research (ITRI) during the 1960s stands as a seminal event credited with instigating Taiwan's successful foray into chip manufacturing (Chang R., 2023). Operating as a government-affiliated non-profit organization, ITRI possesses the overarching objective of propelling advancements in industrial technology. Through its membership structure, ITRI serves as a conduit for government-backed financial assistance, nurturing the growth of R&D initiatives and incubating the world's foremost semiconductor foundries, notably United Microelectronics Corporation

(UMC) founded in 1980 and Taiwan Semiconductor Manufacturing Company Limited (TSMC) founded in 1987.

Under the Tsai Ing-wen administration, a strategic trifold approach was launched to boost domestic R&D. This approach encompasses the amplification of R&D subsidies, the reinforcement of talent cultivation, and the provision of tax incentives for the semiconductor industry (Department of Information Services, 2022). From 2012 to 2022, the Taiwanese government has continually augmented its investments in R&D, with the percentage of GDP allocated to R&D rising from 2.96 per cent to 3.96 per cent (see Table 1).

Table 1. Research and development expenditure in Taiwan from 2012 to 2022

Year	Expenditure (in billion New Taiwan dollars)	Expenditure as GDP (%)
2012	434	2.96
2013	458.43	3
2014	484.54	2.98
2015	511.62	3
2016	541.76	3.09
2017	574.5	3.19
2018	615.99	3.35
2019	660.79	3.49
2020	718.79	3.63
2021	820.63	3.77
2022	898	3.96

Note: The statistical synthesis originated from the datasets published by Statista and the National Science and Technology Council of Taiwan.

In consonance with governmental goals, the government-backed TSMC is one of the pioneers supporting semiconductor R&D endeavours in Taiwan. Since its inception over three decades ago, this company has steadfastly pursued the goal of proprietary technological advancement (TSMC, n.d.). The company's investments directed towards the expansion of semiconductor R&D has increased over time (Macrotrends, 2023). By the year 2022, TSMC had amplified its R&D expenditure to reach $5.47 billion, reflecting a substantial 23 per cent augmentation in comparison to the preceding year (Ting-Fang & Li, 2022). A pivotal milestone in this trajectory unfolded in

July 2023 when TSMC established the first R&D centre in Taiwan. This strategic establishment reflects TSMC's determined endeavour to transcend the realm of technology licensing and head to attaining its own technological mastery (TSMC, 2023).

Beyond the purview of TSMC, the R&D landscape in Taiwan is marked by the presence of approximately 30 prominent international enterprises that have established their R&D centres within the island. The cumulative investments allocated to these initiatives amount to approximately 60 billion NTD (equivalent to $1.9 billion), culminating in a projected annual production value estimated at nearly 340 billion NTD ($10.9 billion). Among the constellation of R&D facilities in the region are Google's largest data centre in Asia and Microsoft's pioneering artificial intelligence (AI) R&D centre (Department of Information Services, 2022).

While its efforts in establishing its position in the design segment are budding, Taiwan early asserts its pre-eminence as the world's principal hub for semiconductor contract manufacturing services (foundry) and harbours the most comprehensive semiconductor supply chain on a global scale, commanding a majority stake exceeding 50 per cent in the international chip foundry market (Wang & Chiu, 2014). Taiwanese corporate entities, prominently led by TSMC and UMC, hold pivotal positions across key dimensions encompassing semiconductor design, fabrication, manufacturing, as well as assembly, testing, and packaging (ATP) procedures (Weinstein, 2023). The aggregate revenue amassed by Taiwan's contract manufacturing entities collectively represents over 60 per cent of the global earnings within this domain during the year 2020. A substantial proportion of foremost US technology conglomerates, including prominent entities such as Apple, Amazon, Google, Nvidia, and Qualcomm, rely extensively on Taiwan-centred contract manufacturers for approximately 90 per cent of their chip requirements (Lee, 2021). In addition, China's dependence on Taiwan for chip imports reaches approximately 36 per cent (Suzuki & Yamashita, 2022). Taiwan's preeminent foundries are also actively expanding their production facilities into countries and regions, including the United States, Japan, Singapore, and Europe (TSMC, n.d.; UMC, n.d.).

Beyond its commendable market share, Taiwan has emerged as a widely recognized leader in the realm of quality within the foundry chip domain. Evidently, TSMC is one of only two corporations globally, alongside Samsung (South Korea), that possesses the capability to fabricate and supply the highly

advanced 5-nanometer chips for the global market (Arcuri & Lu, 2022). Furthermore, TSMC is expected to produce 3-nanometer chips in 2024 (Wu 2022) and to launch 2-nanometer chip technology by 2025 (Wang L., 2023).

In addition to its thriving foundry industry, Taiwan is home to a vast network of chip assembly, testing, and packaging enterprises. Notable names in this sector include Advanced Semiconductor Engineering, Inc. (ASE), Powertech Technology Inc. (PTI), King Yuan Electronics Co., Ltd. (KYEC) and Chipbond. Ahead of the pack, ASE had yearly sales of more than 373 billion Taiwan dollars in 2022 (Slotta, 2023). Along with these organizations, Taiwan has been making strides in building an almost comprehensive indigenous semiconductor value chain.

The narrative of Taiwan's success within the semiconductor industry, marked by its government's unwavering and enduring policy framework, stands as a noteworthy example for nations aspiring to carve a significant niche within this domain. Nonetheless, Taiwan still encounters enduring and substantial challenges on its path to retaining its stature as a key player in global semiconductor value chain. As it strives to attain loftier aspirations concerning R&D autonomy, coupled with its ambition to assume the mantle of Asia's high-tech manufacturing nucleus, Taiwan grapples with obstacles arising from demographic contraction (Focus Taiwan, 2023), the dearth of human resource, as well as the shortage of governmental investment for basic scientific majors (Yamada, 2022).

Future operating dynamics of Taiwan's semiconductor ecosystem are likely to be significantly affected by the issues brought about by an aging population and a dearth of indigenous labour force. The birth rate in Taiwan is currently among the lowest in the world, ranking among the top five. Since 2003, Taiwan's total fertility rate has dropped below 1.2 births per year due to social factors such as delayed marriage, remaining unmarried, childlessness, and late childbirth (National Development Council, n.d.). The National Development Council (NDC) predicts that by 2035, Taiwan would have the world's second-lowest birth rate, surpassing South Korea (Focus Taiwan, 2022). This trajectory is projected to usher the nation into an era of negative population growth (Textor, 2023) and become a super-aged society by 2025, with an elderly demographic expected to make up 20 per cent of the total population (Hsu, 2022). Significant population aging is a clear and present danger that will impart consequential strain upon the workforce and the economy in Taiwan's pivotal industrial sectors.

There is a growing problem in Taiwan with a shortage of qualified workers in STEM occupations, particularly in semiconductor technology, and this is exacerbated by the country's aging population. Taiwan has been facing significant challenges when it comes to recruiting a workforce that can keep up with the rapidly expanding demands of the semiconductor sector, which ranges from high-tech to mature-node chips. There were 23,000 new job vacancies in the semiconductor sector each month during the second quarter of 2023, according to *104 Job Bank*, one of the biggest employment search sites in Taiwan (Chien-ling & Hsiao, 2023). Despite the expansion of Taiwan's semiconductor labour market, there has been a discernible decrease in the number of students graduating from STEM and semiconductor programs in the past ten years (Yang, 2022). From 2011 to 2020, the number of graduate students from these professions in Taiwan fell by 21.31 per cent, and there was a notable 17.15 per cent drop in the enrolment of undergraduates, master's students, and doctoral students in STEM fields between 2012 and 2021 (Ching-hsuan & Tzu-hsuan, 2023). Given the current demographic trajectory, it is quite unlikely that this decline will be reversed anytime soon. Prospects for Taiwan's domestic semiconductor industry are cloudy due to rising demand for engineers and a declining graduating pool.

Another challenge besetting Taiwan's semiconductor industry is the lack of resources for basic research, a prerequisite for the long-term success of Taiwan's semiconductor industry. In 2020, basic research spending only accounted for seven per cent of Taiwan's total R&D spending. This is higher in China, where it has long been just over five per cent but is still far below the 20 per cent commonly found in industrialized nations such as the United States, Japan, and other European countries (Yamada, 2022). Indeed, weaknesses in basic research such as physics, electronics and materials science, technology and management methods have existed throughout since Taiwan entered the semiconductor market in the 1970s (Wang & Chiu, 2014). Taiwan's semiconductor industry is considered crucial for the island to maintain its strategic importance and international alliances amid deteriorating relations with China. As a result, investing in basic research and attracting or exchanging talents in basic research is critical for Taiwan in the long run. Recognizing the issue, the Tsai administration has pledged to invest at least $300 million over the next ten years on education programs to advance the semiconductor industry (Ting-Fang & Li, 2022). However, more efforts need to be catalysed.

In general, Taiwan emerges as a preeminent protagonist within the international landscape of the semiconductor industry. The systematic infusion of investments by the government for the past three decades has substantively propelled Taiwanese semiconductor enterprises not only to commandeer a preponderant share of the global chip foundry market but also to attain a distinctive prominence with regard to product excellence. Notwithstanding these accomplishments, the prospective trajectory of Taiwan's semiconductor industry is beset by substantial challenges rooted in demographic dynamics and a noticeable paucity of investment directed towards fundamental research undertakings. These impediments encumber the potential advancement of Taiwan's semiconductor sector in the immediate future, thereby mandating a concerted governmental endeavour to address these issues in order to sustain the island's "security shield".

3. Vietnam: An Emerging Hub of Manufacturing and Talent in Semiconductor Industry

Vietnam's involvement in the semiconductor sector is not a new phenomenon. In this domain, one significant historical antecedent of Vietnam's engagement with the semiconductor business is the establishment of the original semiconductor facility, Z181, in 1979, with the purpose of producing and exporting semiconductor components to the Soviet Union and Eastern European nations during the Cold War (Vietnam Ministry of Information and Communications, 2023). The fall of the Soviet Union and consequent trade embargoes imposed by great powers on Vietnam signalled the end of Vietnam's early efforts to develop its semiconductor capabilities. In the modern era, Vietnam is gradually re-establishing its position in the global semiconductor value chain.

By the end of 2022, FPT Semiconductor had made significant strides in the field of chip design, allowing Vietnam to make its first steps toward developing its indigenous chips (FPT, 2022). Before being introduced to both local and regional markets including Japan, Australia, and Taiwan, FPT's large-sized chips were processed in two locations: South Korea and Taiwan (Chi, 2023). For Vietnam, this represents a watershed moment on the road to chip design independence. However, a large investment in capital is required to build the country's domestic semiconductor value chain, which is lacking in the fabrication segment. Nevertheless, Vietnam's domestic semiconductor value chain remains a deficiency in the fabrication segment (Gia Cu & Le

Loan, 2022), necessitating a substantial capital investment for development (Intel, n.d.).

Instead, multinational semiconductor businesses have set up manufacturing facilities in Vietnam, leading to tremendous expansion in the assembling, testing, and packaging sectors of the industry in the previous decade. As of June 2023, Vietnam has ascended to the third position among economies engaged in semiconductor exports to the United States, trailing closely behind Malaysia and Taiwan (Kim, 2023). The influx of completed semiconductor chips originating from Vietnam constitutes in excess of 10 per cent of the United States' semiconductor chip imports. This achievement can be attributed to the presence of Intel Products Vietnam (IPV) since 2006, the largest chip assembly and testing facility within Intel Assembly and Test (ATM) network. It is projected that the revenue generated by Vietnam's semiconductor market will attain a sum of $17 billion by the year 2023 (Statista, 2022). This market's landscape is primarily dominated by integrated circuits with an envisaged market valuation of $14 billion in 2023. From 2023 to 2027, revenue derived from Vietnam's semiconductor sector is anticipated to have a compound annual growth rate (CAGR) of 11.03 per cent, poised to culminate in a market worth of $26 billion by the year 2027 (Statista, 2022).

In addition to its incremental penetration within the realm of chip manufacturing, Vietnam has emerged as an ascending production hub within the domain of electronics and smartphones, constituting a downstream component of the global semiconductor value chain. Within this context, Vietnam's trajectory as an exporter of electronics has witnessed a notable ascent, elevating its position from 47th in 2001 to the 12th spot by 2019, which is partly attributed to the geographical realignment of the supply chain from China toward Southeast Asia (Nguyen, 2023). Furthermore, the year 2019 saw Vietnam secure a prominent global standing as the second-largest exporter of mobile phones, with a valuation exceeding $51 billion (Van Anh, 2021). Vietnam's electronics sector remains primarily under the purview of established foreign enterprises, responsible for over 90 per cent of the total exports and an 80 per cent share of the domestic market (Nguyen, 2023). Presently, Vietnam boasts a network of 11 manufacturing facilities entrenched within Apple's supply chain (Vietnam Insider, 2022), while an impressive 50 per cent of Samsung's worldwide mobile phone production emanates from its facilities situated within the country (Hai Yen, 2023). The

evolution of Vietnam's electronics and smartphone manufacturing domains has the potential to enhance its appeal to investors in the upper segments of the semiconductor supply chain, namely designing, manufacturing, installation, and packaging and testing.

As the semiconductor value chain is becoming more localized to enhance its diversity and flexibility, there is an increasing number of corporations specializing in semiconductors seeking opportunities to broaden their investments in the Vietnam. This trend is underscored by notable developments. In August 2022, Synopsys, an electronic design automation corporation headquartered in the United States, formally declared its intent to establish a deeper operational footprint within Vietnam (Bortoletti & Nguyen, 2022). Subsequently, in December of the same year, the Samsung technology conglomerate inaugurated its inaugural R&D centre in Hanoi, representing a substantial investment of $220 million (Huong Giang, 2022). A notable stride in the integration of semiconductor technologies was also evident, as Samsung prepared to initiate trial production of flip-chip ball grid arrays—a pivotal interconnection component between semiconductor chips and mainboards—at the Samsung Electro-Mechanics in Thai Nguyen province (Phan Anh, 2022).

Moreover, the early stages of June 2023 witnessed the establishment of a global branch office in Bac Ninh province by Hanmi Semiconductor, another prominent semiconductor firm based in Korea (Nguyen Thuy, 2023). Concurrently, Amkor Technology Inc., a preeminent semiconductor entity originating from the United States, is poised to inaugurate a manufacturing facility in Bac Ninh by the end of 2023 (Tri Lam, 2023). The trajectory of investment amplification extends further, as ASML, a Netherlands-based corporation that furnishes chip manufacturing equipment to industry giants such as TSMC, Samsung, and Intel, has communicated its strategic intent to extend its investment outreach into the Vietnamese sphere (Tuong Nguyen, 2023). In aggregate, the surging influx of foreign direct investment into Vietnam has affirmed the nation's emergent stature within the global semiconductor landscape.

Beyond the alluring market potential, the substantial labour force characterized by economical remuneration is exerting a magnetic pull on multinational corporations, prompting them to establish manufacturing facilities within the confines of the Southeast Asian nation. Vietnam currently finds itself within a phase denoted as the "golden population", a juncture

wherein over 50 per cent of its populace lies within the working age bracket (ASEAN, 2021). This demographic advantage is further complemented by a distinctive edge vis-à-vis neighbouring nations in the region — a cadre of youthful technical adeptness available at comparatively nominal costs.

Contrasting the scenario, while Taiwan grapples with a pronounced scarcity of STEM graduates, Vietnam boasts an impressive contingent of more than 47 per cent of tertiary-educated individuals specializing in this realm (Vietnam News, 2022). This propels the nation ranking among the top 10 countries worldwide in terms of engineering graduates (McCarthy, 2015). Particularly, there are around 5,000 engineers engaged in IC design, predominantly centred in Ho Chi Minh City (comprising 85 per cent of the total), followed by Hanoi (eight per cent), and Da Nang (seven per cent) (Vietnam Ministry of Information and Communications, 2023).

Vietnam's semiconductor R&D capabilities hold promise as well. By the culmination of 2022, Vietnam had contributed to 1,072 international publications relevant to the semiconductor industry, along with 635 international publications pertaining to microchip technologies (Thi, 2023). Indigenous technology conglomerates, notably FPT and Viettel, are actively cultivating their own chip technology and gaining encouraging accomplishments within this domain.

Vietnam's distinctive attributes vis-à-vis China amplify its appeal as a destination for FDI within the semiconductor sector. The labour cost differential between the two nations further augments this attractiveness. Notably, the remuneration for labour in Vietnam stands at a mere a half of that in China. To elaborate, the minimum wage in Vietnam ranges from approximately $132 to $190 (Dezan Shira and Associates, 2022), while its Chinese counterpart amounts to $359 (Take-profit.org, n.d.). Additionally, geographical proximity with China enhances Vietnam's allure in this context, as Vietnam's northern manufacturing cluster lies within a conveniently accessible 12-hour drive from Shenzhen, the prominent manufacturing epicentre of China (Le & Nguyen, 2022). Consequently, Vietnam emerges as a promising candidate aligning with the strategic "China Plus One" approach pursued by major technology conglomerates such as Samsung, Intel, Apple, and Xiaomi, which are looking to diversify their supply chains beyond China (Leung, 2022).

Amidst the multifaceted drivers underpinning the prospering trajectory of Vietnam's semiconductor sector, the conspicuous role of governmental

investment interest holds paramount significance. Analogous to the stance observed in Taiwan, Vietnamese leaders see the semiconductor industry as pivotal not only from an economic vantage, but also for national security considerations (Le & Nguyen, 2022). Over the preceding two decades, Vietnam with Ho Chi Minh City, the city boasting robust economic ties with Taipei (Taipei Economic and Cultural Office in Vietnam, 2009), as a pioneer, has exhibited well-defined orientations, objectives and strategic undertakings geared toward establishing foundational pillars essential for the nascent semiconductor chip domain.

In the year 2005, Vietnam National University-Ho Chi Minh City embarked on the establishment of the Circuit Design and Training Centre (ICDREC), alongside the Laboratory of Nanotechnology (LNT), subsequently evolved into the Institute of Nanotechnology (INT), engendering the cultivation of human resources attuned to the exigencies of the burgeoning semiconductor chip industry. In the subsequent year, 2006, a pivotal milestone was attained as Saigon Hi-tech Park (SHTP) achieved the successful attraction of Intel to establish an assembly facility within its precincts. This juncture stands as the second salient inflection point in the evolution of Vietnam's semiconductor industry, following Project Z181 in the previous century (Nguyen A. T., 2023). Most recently, in early 2023, the Vietnamese government issued Resolution No. 98/2023/QH15 delineating targeted mechanisms and policies for the developmental advancement of Ho Chi Minh City, in which the semiconductor industry was identified as one of the three priority industries to attract strategic investment (Vietnam Government's Web Portal, 2023).

In the forthcoming period, it is anticipated that the Vietnamese government will persist in crafting novel policy frameworks aimed at fostering foreign direct investment (FDI) within the semiconductor industry and augmenting the nation's standing across the expansive spectrum of the global semiconductor value chain. The proactive inclination towards accommodating investors and facilitating international collaboration in the semiconductor domain, coupled with the intrinsic merits associated with demographic attributes, labour expenditure, and the availability of ample human capital, collectively position Vietnam as an exceedingly fitting collaborator to work with Taiwan in addressing the multifaceted challenges confronted by the island's semiconductor industry.

4. Prospects of Taiwan-Vietnam Semiconductor Industry Collaboration

Vietnam and Taiwan, with their own advantages and weaknesses, should collaborate in the semiconductor industry to boost their economies. R&D and talent exchange, investment, and labour force are the three pillars upon which consolidation can rest. The subsequent analysis provides a more comprehensive examination of the outlined recommendations, with a concise summary presented in Table 2.

Taiwan and Vietnam can gain a lot from enhancing their semiconductor cooperation by concentrating on R&D and exchanging talent, which is the first and most important step. Doing so would greatly benefit both sides by encouraging their scientific communities to work together. Cooperation on scientific projects, use of shared resources, and pooling of funds are all part of this. To further cement its strategic presence in Vietnam, Taiwan could be motivated to think about setting up research and development centres for semiconductors there down the road.

In addition, experts from both countries could learn from one other's experiences and perspectives by participating in expert exchange programs. Vietnamese education and training programs, electrical design expertise, and models driven by cutting-edge technology might all benefit from the active participation of engineers and specialists from Taiwan. Maintaining Vietnam's status as a Southeast Asian semiconductor hub will require a fresh crop of brilliant young electrical designers. The semiconductor industry in Taiwan may be willing to lend Vietnam's high-tech economy a hand by sharing their knowledge and connecting it to their state-of-the-art technologies.

Cooperation in training should also be a top priority; this could be achieved by creating educational programs, seminars, and skill development sessions that would help both sides' talent in the semiconductor domain. In recent years, Taiwan has become a popular destination for Vietnamese students. The number of Vietnamese students studying in Taiwan is expected to surpass 20,000 by the end of 2022, solidifying Vietnam's position as the leading country sending students to Taiwan (Wong, 2023). Since more and more Vietnamese students are enrolling in Taiwanese universities and colleges, the island nation should do more to entice Vietnamese students to major in semiconductor-related subjects, where they may improve their theoretical understanding, practical skills, and employability (Nhat Minh,

2023). Considering that many Vietnamese students have expressed an interest in working for Taiwanese companies in Vietnam after graduation, these students may choose to work for semiconductor companies in Taiwan for a while after finishing school. Then, they may return to Vietnam and put their technical and professional skills to use for Taiwanese businesses there (Sang & Nhung, 2021).

This partnership has the potential to alleviate the semiconductor industry's talent gap in STEM fields and speed up the recovery process of fundamental scientific research in Taiwan. On its side, Vietnam can gain an advantage by exposing its talented individuals in these areas to the developed nation's superior resources and skills, allowing them to reach their full potential and expand their knowledge base. Vietnam aspires to be a leading player in the chip production chain, but it has faced insurmountable structural obstacles, most notably a lack of qualified workers and appropriate technology. Hence, for Hanoi to succeed, Taiwanese cutting-edge technology and expertise play an important role.

It is common practice for countries with higher labour costs to handle the front end of the semiconductor manufacturing process (wafer fabrication and probe testing) while countries with cheaper labour costs handle the rear end (assembly, packaging, and testing) (Mönch, Chien, Dauzère-Pérès, Ehm & Fowler, 2018). This division of responsibilities is applicable in the collaboration between Taiwan and Vietnam, where Taiwan takes charge of the former phase while Vietnam assumes responsibility for the latter phase. The enduring investment commitment of Taiwanese semiconductor enterprises in Vietnam's assembly, packaging, and testing sectors holds the promise of yielding multifaceted benefits. In comparison to their local operations in Taiwan, this strategic endeavour allows them to acquire labour resources and facilities in Vietnam that are more cost-efficient, which in turn reduces production expenditures. To further mitigate the risks associated with being overly reliant on a small number of geographic sites, Taiwan can diversify its relationships for outsourced assembly, packaging, and testing (OSAT) by channelling investments into Vietnam. In the backdrop of US-China strategic competition and the deteriorating relations across the Taiwan Strait, this diverse strategy helps strengthen resilience in the face of geopolitical uncertainty and possible disruptions.

In Southeast Asia, Taiwan's ASE has maintained operations through two assembly and testing facilities in Malaysia and Singapore (ASE, n.d.). In

contrast, other prominent players in this sector, such as PTI and KYEC, have primarily established their factories domestically and in China (PTI, n.d.; KYEC, n.d.). Now is the time for these enterprises to extend their footprint into Vietnam in the waves of the New Southbound Policy. Taiwanese semiconductor manufacturers would do well to reach out to Vietnamese enterprises, as Vietnam is quickly becoming a major semiconductor production hub and, eventually, a potential alternative to China.

Aside from the backend section, Taiwanese enterprises also have the option to move the frontend production lines to Vietnam. These lines are responsible for manufacturing mature nodes, which range from 28 to 75 nanometres in size. The partnership between Taiwan and the United States had a profound impact on the early stages of the semiconductor industry's development. The rise of American chip designers and Taiwanese contract manufacturers in the 1990s was a direct result of developments in communication and automated design (Holmström, Kenney & Seppälä, 2021). As Taiwan seeks to advance and consolidate its new position within the semiconductor value chain, akin to the role the United States played in the US-Taiwan semiconductor cooperation of the 1990s, Taiwan needs a new partner to assume its former role within this cooperative framework. When it comes to filling this job, Vietnam is a strong contender.

Because most modern manufacturing technology is owned by foreign direct investment businesses, Vietnam finds it tough to reach the chip production phase, despite initial advances in the field of large-sized chip design (Thanh Ha & Bao Ngoc, 2023). The aspirational ambition of Vietnam to join the semiconductor design and production industry — which calls for skilled workers and state-of-the-art facilities — may be thwarted by these challenges (Centre for WTO and International Trade, 2023). To accomplish this, Vietnam needs the state-of-the-art knowledge and backing of Taiwan's high-tech semiconductor manufacturing behemoths. Also, Taiwan will still be able to compete with other major chip manufacturing nations that are producing chips with a two-to-three-nanometre pitch even after they transfer their mature node manufacturing capabilities to Vietnam.

As an increasing number of international corporations are looking to increase their footprint in Vietnam, Taiwan should use the opportunity to solidify its position in the Vietnamese market. The fact that the Vietnamese government has rolled out the red carpet for semiconductor businesses, including those from Taiwan, lends credence to this idea. To attract more

investment from competent partners and support the local semiconductor industry, the Vietnamese government has been enacting policies that are advantageous to capable partners. One example is the government's Decision No. 66/2014/QD-TTg, which, among other things, authorized a set of high-tech items eligible for development promotion and a set of high-tech products prioritized for development investment (Phuong Hoa, 2023). This does double duty: it encourages foreign cooperation in the semiconductor business while simultaneously denoting the government's growing focus on high-tech areas.

Vietnam also has an urgent need for qualified researchers and experts in the field of semiconductors since it is planning to become a major player in the Southeast Asian chip manufacturing market (Khanh Khanh, 2022). Bringing in knowledgeable engineers and experts from Taiwan's semiconductor companies, academic institutions, and research groups might solve this problem. As an example, by implementing rigorous R&D programs and offering specialized engineering courses, Taiwanese experts may assist and educate their Vietnamese counterparts in the semiconductor industry.

Last but not least, there are a number of ways in which Taiwan's semiconductor industry can gain from a stronger labour export program from Vietnam to Taiwan inside the semiconductor sector. To begin with, the urgent need for qualified workers in various positions within the semiconductor industry in Taiwan can be met by utilizing a trained workforce from Vietnam, thus reducing the labour deficit in the country. In addition, the semiconductor sector in Taiwan may increase its production capacity and keep up with the rising global demand for semiconductor products by increasing the size of its labour force by hiring talented Vietnamese workers.

The post-COVID-19 period will see an increase in job prospects for Vietnamese people thanks to the constructive engagement between Vietnam and Taiwan. Taiwan, Japan, and South Korea have been considered the top three destinations for Vietnamese labour exports for a number of years (Le Tuyet & Hong Chieu, 2022). Unfortunately, most Vietnamese workers in Taiwan have traditionally been involved in low-skilled, low-paying jobs that the locals are not willing to handle. When it comes to bringing Vietnamese workers into Taiwan for collaboration in the semiconductor industry, a more thoughtful and selective approach is required. It is of the utmost importance to make sure that these persons are qualified and have the abilities that are

needed by Taiwanese companies. Careful and selective hiring will improve workforce quality and maximize contributions of Vietnamese workers to Taiwan's semiconductor industry. This mutually beneficial collaboration can cultivate stronger ties between Taiwan and Vietnam, fostering long-term economic cooperation and bolstering Taiwan's status as a global hub for semiconductor manufacturing.

Table 2. Suggestions for Taiwan-Vietnam Mutually Beneficial Collaboration in the Semiconductor Industry

Sphere of collaboration	Suggestions	Benefits	
		Taiwan	Vietnam
R&D and talent exchange	- Research cooperation - Training cooperation - Expert exchange	- Accelerating the recovery process of basic scientific research - Solving the problem of talent shortage in STEM and semiconductor industry	- Talents in these industries should be given resources in advanced countries to maximize their potential and expertise
Investment	- Taiwan should invest in Vietnam in the assembly, packaging, and testing segments - Taiwan should invest in manufacturing plants using technology as old as mature chip manufacturing technology	- Expanding production lines to increase profits and diversify the value chain - Resolving employment issues for the workforce	- Increasing GDP in the semiconductor industry
Labour force	- Strengthening the labour export program from Vietnam to Taiwan to work in semiconductor sector	- Addressing labour resource shortages - Enhancing production productivity	- Resolving employment issues for the workforce

Note: Compiled by authors.

5. Conclusion

While regional semiconductor companies, particularly those from South Korea, are shifting their semiconductor production lines to Vietnam in order to mitigate the long-term effects of the US-China economic rivalry, Taiwanese firms should follow suit by expanding Taiwanese semiconductor investment in Vietnam. In the face of mounting issues, such as Sino-US competition and the ongoing crisis in Ukraine, which threaten to disrupt

global supply chains, Taiwan should make semiconductor collaboration a new and ambitious strategy for navigating this geo-economic turmoil.

Taiwan has long been a world leader in chip manufacturing, but there are hints that major changes are afoot. As trade tensions between China and its key markets, such as the United States, Japan, and Australia, mount and big chip makers seek to diversify their supply chains, alternatives are being explored, and Vietnam is an appealing option (Nguyen U., 2023). Furthermore, Vietnam is ideally positioned to support Taiwan's chip producers wishing to expand their operations into the country and Southeast Asia, given its low-cost workforce, the government's support for investment in the semiconductor chip industry, and geographical proximity to the Chinese market.

Plans to produce domestic chips domestically have been unveiled as Vietnam seeks to promote self-reliance in the semiconductor sector. However, Vietnam has failed to fabricate any semiconductors domestically. Given its limited capabilities, a scarcity of specialized semiconductor engineers, and a lack of incentives for technology transfer, the Vietnamese government acknowledges that encouraging international semiconductor makers to establish facilities in Vietnam is probably the most sensible strategy. This paves a favourable path for Taiwanese companies wishing to expand their outreach in Vietnam.

In the long run, Taiwan-Vietnam semiconductor collaboration should serve as a catalyst for strengthening pragmatic ties between the two countries, allowing Taiwan to further its commitment to fostering local-to-local and business-to-business ties with the Southeast Asian nation. Taiwan's leadership in semiconductor supply chains provides feasible possibilities for closer collaboration between Taiwan and Vietnam. Taiwan might aid Vietnam through a variety of specific initiatives, including cooperative research and development, internship programs for Vietnamese students and engineers, and academic and technical exchanges between institutions on both sides. As Taiwan has grappled with the shrinking population and severe labour shortages, advocating Vietnamese talents to work in Taiwanese semiconductor manufacturers could benefit the country as Vietnamese engineers and specialists could serve as bridge builders in Taiwan-Vietnam relations. In short, enhancing R&D, education, investment, and labour force ties could help boost Taiwan's standing in Vietnam's strategic calculations, both economically and strategically.

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