LESSONS LEARNED FROM TAIWAN'S SEMICONDUCTOR ECOSYSTEM FOR SCIENCE, TECHNOLOGY, AND POLICIES TO INDONESIA

MOFA TAIWAN FELLOWSHIP 2025 REPORT

ERRY DWI KURNIAWAN, PH.D

MOFA TAIWAN FELLOWSHIP SCHOLAR 2025

RESEARCH FELLOW

NATIONAL RESEARCH AND INNOVATION AGENCY, INDONESIA

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ABSTRACT

This report examines strategic lessons learned from Taiwan's semiconductor policy ecosystem in research and innovation that Indonesia can adapt. Taiwan's semiconductor industry has developed into one of the most advanced in the world, characterized by excellence in manufacturing, R&D, and cross-sector collaboration. This success is supported by synergy between the government, research institutions, universities, and the private sector, as well as comprehensive infrastructure and policy incentives. Through an in-depth analysis of Taiwan's policy pillars, a case study of TSMC, and a SWOT comparison with Indonesia's situation, this report identifies strategic challenges and opportunities for the development of the national semiconductor industry. It also presents several policy recommendations, including strengthening human resources, R&D incentives, developing technology parks, and triple helix collaboration. It is hoped that this report can serve as a starting point for Indonesia to formulate a long-term strategy for building a robust and innovative semiconductor ecosystem.

Keywords: semiconductor, Taiwan, innovation, research, industrial policy, Indonesia, adaptation strategy.

1. INTRODUCTION

The semiconductor industry is the backbone of modern technology, supporting various sectors such as consumer electronics, automotive, communications, and artificial intelligence. The development of semiconductor technology is heavily influenced by a robust research and innovation ecosystem, which involves synergy between government, industry, and academia. Taiwan has become a major player in the global semiconductor sector, particularly with companies like TSMC, a leader in high-tech chip manufacturing.

This report aims to examine and study Taiwan's semiconductor ecosystem policies in supporting research and innovation, in order to provide insights and recommendations for the development of the semiconductor industry in Indonesia. Through an analysis of Taiwan's policies, industrial structure, research collaborations, and innovation strategies, it is hoped that Indonesia can learn important lessons for building a competitive and sustainable semiconductor ecosystem.

2. BACKGROUND OF THE GLOBAL SEMICONDUCTOR ECOSYSTEM

The global semiconductor industry has grown rapidly in recent decades along with advances in digital technology. Major semiconductor companies are located in several regions, including the United States, South Korea, Japan, Europe, and Taiwan. The semiconductor ecosystem encompasses not only chip manufacturing but also materials research, integrated circuit design, production equipment, and support services.

Global competition is intensifying, with chip fabrication technology becoming increasingly complex and expensive. Countries and regions that can build integrated research and innovation ecosystems can maintain their competitive advantage. Taiwan, supported by targeted government policies and synergy between the public and private sectors, has successfully become a major player in the global semiconductor supply chain.

However, challenges such as supply chain dependency, geopolitics, and the need for qualified human resources require adaptive and innovative policy strategies. In this context, understanding Taiwan's approach to building a semiconductor ecosystem is crucial for application in other countries, including Indonesia.

3. HISTORY AND EVOLUTION OF TAIWAN'S SEMICONDUCTOR INDUSTRY

Taiwan's semiconductor industry journey began in the late 1970s and early 1980s with strong support from the government, which had a strategic vision for developing the high-tech sector. At that time, Taiwan lacked a competitive advantage in chip manufacturing, but through focused industrial policies and substantial investment in research and development, Taiwan was able to build a solid foundation for the semiconductor industry.

One major milestone was the establishment of the Industrial Technology Research Institute (ITRI) in 1973, which served as a technology research centre and innovation incubator. ITRI played a crucial role in technology transfer and fostering semiconductor start-ups. In the early 1980s, Taiwan Semiconductor Manufacturing Company (TSMC) was established as the world's first chip foundry focused solely on manufacturing third-party chip designs, an innovative business model that later became the global industry standard.

Over time, Taiwan developed an integrated ecosystem encompassing fabless chip design companies, equipment manufacturers, raw material suppliers, and research and educational institutions. The Taiwanese government provides fiscal incentives, infrastructure facilities, and research policy support to strengthen collaboration between stakeholders.

This transformation has made Taiwan a dominant player in the global semiconductor market, particularly in high-tech chip fabrication node such as 7nm and 5nm, which serve as the backbone for various cutting-edge electronic products. Taiwan's success in building a semiconductor ecosystem demonstrates the importance of policy synergy, research investment, and innovative business models.

4. TAIWAN'S KEY POLICY PILLARS IN DEVELOPING A SEMICONDUCTOR ECOSYSTEM

Taiwan's success in developing a competitive semiconductor ecosystem is inseparable from the strategic policies implemented by the government and relevant institutions. Several key policy pillars that underpin this industry's development include:

1. **Targeted Investment in Research and Development (R&D)**

   The Taiwanese government consistently allocates substantial funding to support basic and applied research in the semiconductor sector. Through institutions such as the Industrial Technology Research Institute (ITRI) and the Taiwan Semiconductor Research Institute (TSRI), National Applied Research Laboratories (NARLabs), the government facilitates technological innovation that can then be adopted by the industry.

2. **Industry Empowerment Through Fiscal Incentives and Supportive Regulations**

   Taiwan provides various tax incentives, subsidies, and regulatory relief for semiconductor companies, particularly those investing in research and development. This encourages companies to increase their innovation capacity and expand their production facilities.

3. **Development of Technology Infrastructure and Industrial Parks**

   The government is establishing technology parks and industrial parks specifically for semiconductors, which provide modern facilities, high connectivity, and a collaborative environment between companies and research institutions. An example is the Hsinchu Science Park, which is a centre for high-tech innovation and manufacturing.

4. **Collaboration Between Government, Industry, and Academia (Triple Helix Model)**

   Taiwan's policy emphasizes synergy between government research institutions, universities, and private companies in developing new technologies and producing qualified professionals. Joint programs and collaborative funding are crucial instruments in this ecosystem.

5. **Human Resource Development and Higher Education**

   Taiwan strengthens engineering and science education with a focus on semiconductors and provides continuous training for the industrial workforce. This policy ensures the availability of human resources capable of keeping pace with rapid technological developments.

6. **Internationalization Strategy and Supply Chain Resilience**

   Taiwan actively builds business and research relationships with other countries and develops supply chain diversification strategies to mitigate geopolitical risks and global supply disruptions.

With these policy pillars, Taiwan is creating a dynamic and innovative semiconductor ecosystem that is adaptable to technological and global market changes.

5. THE ROLE OF RESEARCH INSTITUTIONS AND UNIVERSITIES IN TAIWAN'S SEMICONDUCTOR ECOSYSTEM

Research institutions and universities play a central role in supporting the development of the semiconductor ecosystem in Taiwan. They serve as centres of technological innovation, producers of skilled human resources, and bridges between basic research and industrial applications.

1. **Industrial Technology Research Institute (ITRI)**

   Founded in 1973, ITRI is an applied research institution that serves as a driving force for technological innovation in Taiwan. ITRI actively develops semiconductor technology in collaboration with industry and the government, provides prototypes, and assists with technology transfer to companies. Through its incubation program, ITRI also supports the establishment of high-tech start-ups.

2. **Universities and Higher Education Programs**

   Leading universities in Taiwan, such as National Taiwan University (NTU), National Tsing Hua University (NTHU), and National Yang Ming Chiao Tung University (NYCU), have specialized faculties and programs focused on electrical engineering, materials science, and semiconductor technology. They produce high-quality graduates ready to fill the workforce needs of the semiconductor industry.

3. **Multidisciplinary Research Collaboration**

   Research institutions and universities actively undertake collaborative projects with industry and government in the form of joint research, technology development, and expert training. This collaboration is facilitated by government policies that provide joint research funding and support triple helix partnerships (government, academia, industry).

4. **Research Centres and Technology Incubators**

   Several specialized semiconductor research centres and start-up incubators are located within technology parks such as the Hsinchu Science Park, enabling

knowledge exchange and accelerating innovation. This environment facilitates the transfer of technology from the laboratory to real-world industrial applications.

5. **Focus on Market-Oriented Research and Sustainable Innovation**

   Taiwan's research institutions focus not only on basic research but also on research that leads to practical applications and the development of new products that are competitive in the global market. This approach fosters continuous innovation in chip fabrication technologies, new materials, and advanced semiconductor devices.

Overall, the strategic role of research institutions and universities in Taiwan's semiconductor ecosystem forms a strong foundation for technological development and industrial competitiveness, and creates effective synergies between research, education, and industry.

6. GOVERNMENT INCENTIVES FOR R&D AND INNOVATION

The Taiwanese government views research and development (R&D) as a key factor in maintaining the competitiveness of the semiconductor industry. Therefore, various incentives and special policies are implemented to encourage companies and research institutions to continue innovating.

1. **Tax Incentives for Research and Development**

   The Taiwanese government provides tax breaks in the form of income tax reductions or exemptions for companies investing in semiconductor technology research and development. This incentive aims to reduce costs and increase companies' budget allocations for innovation.

2. **Subsidies and Research Project Support Funds**

   In addition to tax incentives, the government provides grants and subsidies for research projects with high technological potential and significant impact on the industry. These funds are generally channelled through institutions such as the ITRI (Indonesian Institute of Technology), the Ministry of Economic Affairs, and national research agencies.

3. **Facilitating Public-Private Research Collaboration**

   The government encourages collaboration between private companies, research institutions, and universities by providing joint funding and facilitating applied research programs. This model enhances the effectiveness of technology transfer and accelerates new product innovation.

4. **Development of Supporting R&D Infrastructure**

   The government supports investments in research laboratories, prototyping facilities, and cutting-edge manufacturing technology to provide companies and research institutions with comprehensive facilities to conduct experiments and develop new technologies.

5. **Training and Development of Innovative Human Resources**

   In addition to direct incentives, the government also supports training programs, scholarships, and human resource capacity building focused on innovation and research. This is crucial to ensure the sustainability of R&D and the rapid adoption of new technologies.

6. **Intellectual Property (IP) Protection**

   Taiwan has strengthened its patent and intellectual property protection system to encourage innovation and guarantee the security of corporate research and innovation outcomes. This protection has increased companies' confidence in investing in R&D.

With these incentives, Taiwan has been able to create a vibrant research and innovation ecosystem, thus maintaining its position as a global leader in semiconductor technology.

7. PUBLIC-PRIVATE COLLABORATION IN TAIWAN'S SEMICONDUCTOR ECOSYSTEM

One of the keys to the success of Taiwan's semiconductor ecosystem is the close collaboration between the public and private sectors. This collaboration accelerates the innovation and adoption of new technologies, while strengthening the industry's competitiveness.

1. **Triple Helix Model**

   Collaboration between government, universities, and industry—known as the Triple Helix model—is the foundation for semiconductor technology development. The government provides policies and funding, universities and research institutions contribute to research and development, and industry implements innovations in products and manufacturing processes.

2. **Joint Research and Technology Incubation Programs**

   The Taiwanese government actively facilitates joint research programs between companies and research institutions to develop new technologies. Technology incubators and innovation centres established in areas such as the Hsinchu Science Park support start-ups and small companies in their growth with mentoring and access to facilities.

3. **Knowledge and Expert Exchange**

   This collaboration also includes the mobility of experts between academia and industry, accelerating technology transfer and improving the quality of innovation. Regular seminars, workshops, and conferences serve as platforms for knowledge sharing and networking.

4. **Strategic Partnerships and Industry Alliances**

   Major semiconductor companies and material and equipment suppliers are forming strategic partnerships to develop robust and innovative supply chains. The government supports this cross-sector collaboration with facilitating regulations and fiscal incentives.

8. START-UP AND INNOVATION ECOSYSTEM IN TAIWAN

Taiwan's start-up ecosystem is an integral part of its sustainable semiconductor innovation strategy. The government and institutions support the growth of start-ups focused on high-tech and innovative solutions.

1. **Start-up Incubation and Acceleration Facilities**

   Taiwan offers various incubation and acceleration programs that facilitate start-ups from the early stages to market expansion. These programs offer funding, technical guidance, market access, and extensive business networks.

2. **Venture Capital Funding and Investment**

   A robust funding ecosystem, including venture capital, angel investors, and government funds, supports semiconductor and related technology start-ups. This encourages the research and development of innovative products with global market potential.

3. **Connectivity with Major Industries**

   Start-ups in Taiwan can leverage partnerships with major semiconductor companies to test and adopt new technologies. These relationships accelerate the commercialization of innovations and strengthen start-ups' position in the supply chain.

4. **Innovation Culture and Policy Support**

   A work culture that is innovative and open to new technologies is fostered by government policies that promote creativity and tolerance for business risk. This policy creates a conducive environment for the development of disruptive ideas and solutions.

5. **The Role of Technology Parks**

   Areas like the Hsinchu Science Park serve not only as major industrial hubs but also as spaces for start-ups to thrive, supported by comprehensive infrastructure and network access.

9. HUMAN RESOURCE DEVELOPMENT AND EDUCATION STRATEGY

High-quality human resources (HR) are a critical foundation for an innovative and sustainable semiconductor ecosystem. Taiwan is implementing various strategies to develop a skilled workforce ready to face the challenges of rapidly changing technologies.

1. **Strengthening Higher Education and Engineering**

   Taiwan's universities offer leading engineering and science programs focused on semiconductors, microelectronics, and materials technology. The curriculum is tailored to industry needs and is continuously updated to reflect the latest technological developments.

2. **Training and Continuing Education**

   In addition to formal education, the government and industry provide ongoing technical training and competency development programs for the existing workforce. This includes professional certification, workshops, and hands-on training.

3. **University-Industry Collaboration**

   Close collaboration between universities and companies encourages students to engage in research projects, internships, and cooperative programs. This approach accelerates knowledge transfer and prepares graduates to be job-ready and innovative.

4. **Global Scholarship and Recruitment Program**

   Taiwan provides scholarships for students and researchers and actively recruits foreign talent with high-level expertise in the semiconductor field. This program strengthens national research and innovation capacity by accommodating a diverse range of international expertise.

5. **Soft Skills and Leadership Development**

   In addition to technical expertise, education in Taiwan also emphasizes the development of soft skills such as communication, teamwork, and project management skills, which are essential in a high-tech workplace.

10. INFRASTRUCTURE AND TECHNOLOGY INDUSTRIAL PARKS

The development of infrastructure and specialized industrial parks is a key factor in Taiwan's success in building a robust and innovative semiconductor ecosystem.

1. **Hsinchu Science Park (HSP)**

   Hsinchu Science Park is Taiwan's premier technology park specifically designed to accommodate semiconductor, electronics, and other high-tech companies. HSP provides production, research, and development facilities, supported by modern infrastructure such as high-speed communication networks and efficient logistics.

2. **High-Tech Support Facilities**

   The industrial park features advanced laboratories, prototyping centres, and production facilities capable of supporting cutting-edge chip manufacturing

processes. This infrastructure enables companies to conduct research and production within a single, integrated ecosystem.

3. **Environmental and Security Management**

   The management of the industrial park takes environmental and security aspects into account, creating a healthy and safe working environment for workers and supporting the sustainability of industrial operations.

4. **Accessibility and Connectivity**

   This industrial park is designed with good transportation access and high connectivity to airports, ports, and distribution centres, facilitating the movement of goods and people and streamlining the global supply chain.

5. **Development of Other Technology Parks**

   In addition to Hsinchu, Taiwan is also developing other technology parks such as the Southern Taiwan Science Park and Central Taiwan Science Park to expand its industrial and research base and distribute economic activity regionally.

11. INTERNATIONAL RELATIONS AND SUPPLY CHAIN RESILIENCE

Taiwan recognizes the importance of building strong international relationships and developing supply chain resilience to maintain its strategic position in the global semiconductor industry.

1. **Global Cooperation and Strategic Alliances**

   Taiwan actively forges partnerships with countries and international companies through trade agreements, joint research projects, and technology alliances. This collaboration enables access to cutting-edge technology and a broad global market.

2. **Supply Chain Diversification**

   To reduce the risk of dependence on a single source or region, Taiwan encourages diversification of suppliers of raw materials, equipment, and supporting services. This strategy increases flexibility and resilience to disruptions such as geopolitical tensions and pandemics.

3. **Overseas Investment and Strategic Relocation**

Taiwanese semiconductor companies invest and establish production facilities in various countries to strengthen their global supply chains while also addressing domestic political and regulatory uncertainty.

4. **The Government's Role in Economic Diplomacy**

   The Taiwanese government uses economic diplomacy to strengthen bilateral and multilateral relations and facilitate the penetration of semiconductor products and technologies into international markets.

5. **Technological Resilience and National Security**

   As a country of strategic importance, Taiwan has developed policies to protect critical technologies and ensure supply chain security, including regulating sensitive exports and foreign investment.

12. CASE STUDY: TSMC AS A MODEL OF SUCCESS

Taiwan Semiconductor Manufacturing Company (TSMC) is a prime example of the success of Taiwan's semiconductor ecosystem and a pioneer in the global foundry industry.

1. **Foundry Business Model**

   TSMC is the world's first foundry company to separate chip design and manufacturing. This model enables fabless chip design companies to produce their products without having their own manufacturing facilities, accelerating innovation and efficiency.

2. **Substantial Investment in R&D and Technology**

   TSMC consistently allocates a significant percentage of its revenue to research and development, focusing on cutting-edge fabrication technologies such as 7nm, 5nm, and even 3nm. This investment maintains TSMC's position as a technology leader.

3. **Collaboration with the Government and Research Institutions**

   TSMC works closely with the Taiwanese government and research institutions such as ITRI to develop new technologies and strengthen the innovation ecosystem.

4. **Supply Chain Management and Operations**

   TSMC has integrated and flexible supply chain management, enabling rapid response to market changes and global disruptions.

5. **Economic and Global Impact**

   TSMC's success has not only boosted Taiwan's semiconductor industry but also significantly contributed to the country's economy, making Taiwan a global chip manufacturing hub.

13. SWOT ANALYSIS OF TAIWAN'S SEMICONDUCTOR ECOSYSTEM

To understand the strengths and challenges facing Taiwan's semiconductor ecosystem, here is a comprehensive SWOT analysis:

Strengths:	
• Advanced technological infrastructure and specialized industrial parks such as the Hsinchu Science Park.	• Advanced foundry business model with TSMC as a global leader.
• Strong government support in the form of incentive policies, research, and education.	• Close collaboration between government, industry, and academia (triple helix).
• Skilled and experienced human resources in the semiconductor field.	• Global reputation and extensive international business network.

Weaknesses:	
• High dependence on global supply chains, especially for raw materials and equipment.	• Relatively high production costs compared to some other countries.
• Geopolitical risks due to Taiwan's politically sensitive position.	• Limited natural resources and local raw materials.

Opportunities:	
• Growing global demand for high-tech chips.	• Potential investment expansion in emerging technology areas.
• Technological advances such as AI, IoT, and 5G are opening new markets.	• Intensifying international collaboration in research and manufacturing.

Threats:	
• Fierce competition from countries such as South Korea, China, Japan, and the United States.	• Changes in international trade regulations and policies.
• Supply chain disruptions due to geopolitical conflicts and the pandemic.	• Challenges of rapid technological innovation and the need for significant investment.

14. COMPARISON WITH THE INDONESIAN SEMICONDUCTOR ECOSYSTEM

Indonesia is currently in the early stages of semiconductor ecosystem development compared to Taiwan. Here are some key comparative aspects:

1. **Infrastructure and Industrial Estates**
   Indonesia has several industrial estates, but none are as focused and advanced as the Hsinchu Science Park in Taiwan. Supporting high-tech infrastructure still needs to be developed.
2. **Government Policies and Incentives**
   The Indonesian government has begun issuing policies related to semiconductor industry development, but incentives and research support are still limited compared to Taiwan.
3. **Research and Education Institutions**
   Indonesia has educational and research institutions, but there are no institutions focused and integrated specifically in the semiconductor sector with sufficient capacity.
4. **Public-Private Collaboration**
   The triple helix model in Indonesia is not yet optimal. Collaboration between universities, industry, and the government still needs to be strengthened and facilitated.
5. **Human Resources**
   The availability of skilled technical human resources in the semiconductor sector is still limited in Indonesia, with the need for more intensive training and education.

6. **Start-up and Innovation Ecosystem**

   Indonesia still has very few semiconductor and high-tech start-ups, with inadequate ecosystem support.

7. **Supply Chain Resilience and International Relations**

   Indonesia remains dependent on imported components and raw materials and lacks a robust, integrated supply chain strategy.

15. SWOT ANALYSIS OF THE INDONESIAN SEMICONDUCTOR ECOSYSTEM

To understand Indonesia's position and challenges in developing a semiconductor ecosystem, here is a relevant SWOT analysis:

Strengths:	
• Large and growing domestic market potential for electronic products.	• Strategic geographic position in Southeast Asia, which could become a regional hub.
• Government support, which is beginning to pay attention to the development of the high-tech industry.	• Availability of natural resources for several supporting raw materials.

Weaknesses:	
• Minimal and unfocused technological infrastructure and industrial areas.	• High dependence on imported components and technology from abroad.
• Limited specialized research institutions and skilled human resources in the semiconductor sector.	• Lack of a high-tech start-up ecosystem specifically for semiconductors.
• Low level of collaboration between academia, industry, and government.	

Opportunities:	
• Global trends driving the decentralization of semiconductor manufacturing to reduce supply chain risks.	• Potential collaboration with developed countries and foreign investors.

• Advances in digital technology and the demand for semiconductors in the automotive, telecommunications, and consumer electronics sectors.	• Human resource development and research programs that can be improved.

Threats:	
• Intense global competition and rapidly changing technology.	• Limited funding and investment for research and development.
• Risk of dependence on foreign technology and lack of industrial independence.	• Economic and political disruptions that could hamper industrial development.

16. CHALLENGES FACING INDONESIA IN DEVELOPING A SEMICONDUCTOR ECOSYSTEM

Indonesia faces several significant challenges in building a competitive and innovative semiconductor ecosystem:

1. **Limited Technological Infrastructure**
   The availability of high-tech industrial estates and production facilities remains very limited, hampering the ability to produce cutting-edge chips.
2. **Inadequate Human Resources**
   The number of experts and trained technicians in the semiconductor sector still falls short of industry needs, making human resource development a top priority.
3. **Low Investment in Research and Development**
   Funding for research and innovation remains insufficient, both from the government and the private sector, resulting in slow technological innovation.
4. **Limited Collaboration and Synergy**
   Collaboration between universities, research institutions, and industry is less than optimal, making it difficult to integrate and commercialize technology and innovation.
5. **Dependence on Imported Technology and Components**

Indonesia remains heavily dependent on imported raw materials, equipment, and technology from other countries, which poses risks to the sustainability of the industry.

6. **Regulations and Policies That Are Not Optimally Supportive**

   Several regulations and policies do not fully support the development of the semiconductor industry, including in terms of incentives and intellectual property protection.

7. **Global Competition and Geopolitics**

   Indonesia must be able to compete in a highly competitive global market and face geopolitical challenges that impact the global supply chain.

17. ADAPTATION STRATEGIES AND POLICY IMPLICATIONS FOR INDONESIA

Based on Taiwan's success and the challenges facing Indonesia, here are some adaptation strategies and policy implications to consider:

1. **Strengthening Technology Infrastructure and Industrial Parks**

   Indonesia needs to develop dedicated technology parks with modern facilities for semiconductor manufacturing, similar to the Hsinchu Science Park in Taiwan. Investment in research and production infrastructure should be prioritized.

2. **Increasing Research and Development Investment**

   The government should increase funding allocations for R&D and encourage the private sector to invest in innovation. Tax incentives and research subsidies can accelerate domestic technological development.

3. **Human Resource Development**

   Engineering education and research should be strengthened with relevant curricula, continuous training, and university-industry collaboration to produce a high-quality workforce.

4. **Strengthening Triple Helix Collaboration**

   Building strong partnerships between government, academia, and industry to support joint research, technology development, and the commercialization of innovation.

5. **Start-up and Innovation Ecosystem Development**

Encourage the emergence of high-tech start-ups by providing access to funding, incubation, and business networks that support disruptive innovation.

6. **Supply Chain Resilience Strategy and Economic Diplomacy**

   Reduce dependence on imports by diversifying sources of raw materials and components, and strengthening bilateral and multilateral relationships for supply security.

7. **Improved Intellectual Property Regulation and Protection**

   Simplify regulations and strengthen the patent protection system to create an investment climate conducive to innovation.

18. RECOMMENDATIONS FOR THE INDONESIAN GOVERNMENT

Based on the analysis and adaptation strategies, the following recommendations are presented to the Indonesian government to accelerate the development of the semiconductor ecosystem:

1. **Establish a Special Agency or National Semiconductor Committee**

   To coordinate policy, research, investment, and cross-sector collaboration in an integrated manner.

2. **Increase Research Funding and Fiscal Incentives**

   Provide dedicated funds for semiconductor research and provide tax incentives and investment facilitation for high-tech companies.

3. **Build Technology Zones and Supporting Infrastructure**

   Develop high-tech industrial zones with complete facilities, research laboratories, and good logistical access.

4. **Strengthen Human Resources Education and Training**

   Increase the capacity of higher education and vocational training with a focus on semiconductor technology and innovative research.

5. **Encourage Triple Helix Collaboration**

   Facilitate active partnerships between universities, research institutions, and industry through joint funding programs and innovation initiatives.

6. **Build a Start-up Ecosystem and Innovation Funding**

Support technology start-ups through incubation and acceleration programs, as well as access to venture capital and investors.

7. **Supply Chain Diversification and Security Strategy**

   Encourage the development of local raw materials and international collaboration to secure critical technology supply chains.

8. **Strengthen the Intellectual Property Protection System**

   Improve the patent and copyright system to protect innovation and encourage research investment.

Implementation of these recommendations is expected to accelerate Indonesia's transformation into a significant player in the global semiconductor industry.

19. CONCLUSIONS AND FUTURE PROSPECTS

Taiwan's semiconductor ecosystem is a shining example of how synergy between government policy, research, industry, and human resources can create a globally competitive high-tech industry. With substantial investment in research and development, modern infrastructure, and close triple helix collaboration, Taiwan has been able to dominate the market for high-tech chip manufacturing.

Indonesia, on the other hand, still faces various challenges, such as limited infrastructure, human resources, and research investment, which need to be addressed immediately. However, with its significant market potential and increasingly strong policy support, Indonesia has the opportunity to develop a sustainable semiconductor ecosystem.

Through the adoption of appropriate adaptation strategies and the implementation of policy recommendations, Indonesia can accelerate the development of domestic semiconductor technology, increase industrial value-added, and reduce dependence on imports. The long-term outlook involves strengthening Indonesia's position in the global supply chain and making significant contributions to the growth of the national digital and high-tech economy.

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We hope this report can make a tangible contribution to the development of semiconductor industry policy in Indonesia and inspire stakeholders in building the future of the national technology industry.