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„Between Integration, Indigenization and
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Asia 1991–2021“

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Abstract

Since 1991, East Asian arms industries have increasingly become capable of supplying high technology defence products. Both China and South Korea have emerged as major international arms exporters. Together with Japan, these three nations field the most capable armed forces within the region, supported by defence industrial bases with the capacity of fulfilling domestic demand. Considering this development, the global shift towards a “transitionary” defence sector, and the increased attention to “defence innovation”, the thesis examines the factors enabling this ascent.

First, the author develops an analytical framework specifically designed for defence innovation systems (DIS), based on the national systems of innovation (NSI) approach. Second, the Chinese, Japanese and South Korean DIS, and their sectoral transformations and defence industrial policy adaptations, are assessed as case studies for the period from 1991 to 2021. Third, the case studies are compared and analysed with the indicators provided by the analytical framework.

The comparison shows that similarities between the three DIS have indeed increased during the assessment period. Governments have focused on organizational centralization, the intense promotion of linkages and knowledge diffusion, the liberalization of investments and market access, and the utilization of financial nurturing mechanisms. Despite these similarities, considerable differences continue to exist. Considering the parallels to Western efforts in this field, no distinct “East Asian model of defence innovation” can be identified.

Abstract

Seit 1991 ist die ostasiatische Rüstungsindustrie zunehmend in der Lage, Hochtechnologie für die militärische Anwendung zu liefern. Sowohl China als auch Südkorea sind zu wichtigen internationalen Waffenexporteuren aufgestiegen. Zusammen mit Japan verfügen diese drei Länder über die leistungsfähigsten Streitkräfte in der Region, untermauert von einer einheimischen Rüstungsindustrie mit der Fähigkeit den damit verbundenen Bedarf zu decken. In Anbetracht dieser Entwicklung, des weltweiten Wandels hin zu einem "Übergangs"-Verteidigungssektor und der verstärkten Aufmerksamkeit für "Verteidigungsinnovation", werden in dieser Arbeit die Faktoren untersucht, die diesen Aufstieg ermöglicht haben.

Zunächst entwickelt der Autor einen Analyserahmen speziell für Verteidigungsinnovationssysteme (defence innovation systems - DIS), der auf dem Forschungsansatz der nationalen Innovationssysteme (national systems of innovation - NSI) beruht. Zweitens werden die chinesische, japanische und südkoreanische DIS, sowie deren Transformation und die Veränderung der Verteidigungsindustriepolitik, als Fallstudien im Zeitraum von 1991 bis 2021 untersucht. Drittens werden die Fallstudien im Rahmen der vom Analyserahmen bereitgestellten Indikatoren verglichen und analysiert.

Der Vergleich zeigt, dass die Ähnlichkeiten zwischen den drei DIS während des Bewertungszeitraums zugenommen haben. Die jeweiligen Regierungen haben sich auf die organisatorische Zentralisierung, die intensive Förderung von Netzwerken und Wissensverbreitung, die Liberalisierung von Investitionen und Marktzugang, sowie finanzielle Förderungsmechanismen konzentriert. Trotz dieser Gemeinsamkeiten gibt es weiterhin erhebliche Unterschiede. In Anbetracht der Parallelen zu westlichen Bemühungen in diesem Bereich lässt sich kein eindeutiges "ostasiatisches Modell der Innovation im Verteidigungsbereich" abgrenzen.

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Abbreviations

A) General Terms

C4ISR	Command, control, communications, computers, intelligence, surveillance, and reconnaissance
DARPA	Defense Advanced Research Projects Agency
DCS	Direct Commercial Sales (United States)
DIB	Defence industrial base
DIP	Defence industrial policy
DIS	Defence innovation system
DIU	Defense Innovation Unit (United States)
DPA	Defence procurement agency
EDF	European Defence Fund (EU)
EDIDP	European Defence Industrial Programme (EU)
FMS	Foreign Military Sales (United States)
GDP	Gross domestic product
I(C)T	Information (and communication) technology
IPR	Intellectual property rights
ITAR	International Traffic in Arms Regulations (United States)
MoU	Memorandum of Understanding
NATO	North Atlantic Treaty Organization
NDO	National defence organization
NSI	National system(s) of innovation
NTBF	New-technology-based firms
OECD	Organisation for Economic Co-operation and Development
PADR	Preparatory Action on Defence Research (EU)
R&D	Research and development
RMA	Revolution in Military Affairs
RTDI	Research, technology, development, and innovation
SIM	Strategic innovation system management
SIPRI	Stockholm International Peace Research Institute

ABBREVIATIONS

SME	Small- and medium enterprise
SOE	State-owned enterprise
S&T	Science and Technology
STI	Science, technology, and innovation
TIV	Trend Indicator Value (by SIPRI)
TRL	Technological Readiness Level
WMD	Weapons of mass destruction

B) China

863-plan	National High-tech R&D Programme
995-plan	995 High-Technology Development Plan
CCP	Chinese Communist Party
CICMD	Commission for Integrated Civilian-Military Development
CMC	Chinese Military Commission
CMI	Civilian-military integration
COSTIND	Commission on Science, Technology and Industry for National Defence
DIEG	Defence industrial enterprise group
EDD	Equipment Development Department (CMC)
GAD	General Arms Department (CMC)
GLD	General Logistics Department (CMC)
GSD	General Staff Department (CMC)
MCF	Military-civilian fusion
MIIT	Ministry of Industry and Information Technology
MLDP	Medium- and Long-Term Defence Science and Technology Development Plan
MOST	Ministry of Science and Technology
MRO	Military representative offices
MSG	Military Strategic Guidelines
MSRSC	Military Science Research Steering Committee (CMC)
NDIP	National Defence Intellectual Property Office
NDRC	National Development and Reform Commission

ABBREVIATIONS

PLA	People's Liberation Army
PLAN	People's Liberation Army Navy
PMC	Provincial Military Commands (PLA)
PolyTech	Poly Technologies (China Poly Group Corporation)
PRC	People's Republic of China
SACMPT	State Administrative Committee on Military Product Trade
SASAC	State-owned Asset Supervision and Administration Commission (State Council)
SASTIND	State Administration for Science, Technology and Industry for National Defence
SCFA	Strategic Cooperation Framework Agreements
SEC	State Economic Commission (State Council)
SEI	Strategic Emerging Industries (Initiative)
SPC	State Planning Commission (State Council)
SSTC	State Science and Technology Commission (State Council)
STC	Science and Technology Commission (CMC)
WECP	Weapons and Equipment Construction Plans
WEDS	Weapons and Equipment Development Strategies
WEIAN	Weapons Acquisition Information Network

Defence enterprise abbreviations are listed in Table 14

C) Japan

ATLA	Acquisition, Technology & Logistics Agency
DTO	Defence Technology Outlook
DTS	Defence Technology Strategy
ImPACT	Impulsing Paradigm Change through Disruptive Technologies Programme
JDA	Japanese Defence Agency
JMoD	Japanese Ministry of Defence
JST	Japan Science and Technology Agency
METI	Ministry of Economy, Trade and Industry (formerly MITI)
MHI	Mitsubishi Heavy Industries
MITI	Ministry of International Trade and Industry

ABBREVIATIONS

MOF	Ministry of Finance
MOFA	Ministry of Foreign Affairs
MTDP	Mid-Term Defence Programme
NDPG	National Defence Programme Guideline
SDF	Self-Defence Forces
TRDI	Technical Research and Development Institute (JDA)

Defence enterprise abbreviations are listed in Table 20

D) South Korea

ADD	Agency for Defence Development
ADO	Acquisition Development Office (MND)
AFROK	Armed Forces of the Republic of Korea
DAPA	Defence Acquisition Programme Administration
DAO	Defence Acquisition Office (formerly ADO) (MND)
DQAA	Defence Quality Assurance Agency
DSME	Daewoo Shipbuilding & Marine Engineering
DTAQ	Defence Agency for Technology and Quality
FIP	Force Improvement Programme (Force Enhancement Programme)
HHI	Hyundai Heavy Industries
ICMTC	Institute of Civil-Military Technology Cooperation
JCS	Joint Chiefs of Staff
KAI	Korea Aerospace Industries
KARI	Korea Aerospace Research Institute
KIDA	Korean Institute for Defence Analyses
KNDU	Korea National Defence University
MND	Ministry of National Defence
MOTIE	Ministry of Trade, Industry and Energy
MSIT	Ministry of Science and ICT
PPBEE(S)	Programming, Budgeting, Execution and Evaluation (System)
ROK	Republic of Korea

1. Introduction

1.1. East Asia in the Global Arms Trade

The position of East Asia within the global arms trade has considerably shifted since the end of the Cold War. In the late 1990s, East Asian countries were the destination of a third of global imports, but until 2020 this share had declined to less than 18 percent (SPRI 2021a). In the same period the region's global share of military expenditure had risen from 8 percent to more than 20 percent (SIPRI 2021b). Its share of arms exports also grew from 3.5 percent in 1990 to 7 percent in 2020 (SPRI 2021a).

This trend is primarily driven by North East Asian countries. China and South Korea alone were responsible for 97 percent of regional arms exports, with the first becoming a net arms exporter in the 2010s (SIPRI 2021a). Growing arms exports and falling arms imports, in parallel to rising defence budgets, clearly pinpoint to the region's growing defence industrial capacity and supply reliance. SIPRI's (2021a) Arms Transfers Database supports the conclusion that China, South Korea and Japan command the most potent defence industries within the region, both in respect of arms exports and defence firms listed in the global top-100 ranking. East Asia accounts for 16 percent of the top-100 global defence companies, placing it just behind North America and Europe. Except for one enterprise from Singapore, all of them originate from the three countries named above (SIPRI 2021a).

While Japan has not emerged as a major arms exporter due to self-imposed restrictions that were only abolished in 2014, its defence enterprises are clearly represented in the global ivy league. While the country has the second biggest defence budget in the region, it accounted for just 8 percent of defence imports. Its domestic industry is thus capable of fulfilling the bulk of internal demand (SIPRI 2021a).

The data thus begs the question, how these three countries' defence industries managed to become internationally competitive. What reforms and policies have been implemented to make Chinese and South Korean defence industrial bases competitive on the global market? Why is the Japanese defence industrial base capable of fulfilling the domestic demand of the armed forces, considering its long-standing arms export and international defence cooperation bans? Did these nations implement similar reforms and strategies or differing ones?

Defence industrial reforms in Western countries increasingly promote the concept of "defence innovation", as outlined in more detail in sub-chapter 2.6.3. This poses the subsequent question, in how far undertakings in East Asia mirror or differ from Western approaches. Have the

countries in question developed policy tools to boost defence innovation, and if so, do they present an East Asian model of defence innovation?

1.2. Research Approach

Comparing the three most capable nations – in respect of the size of the defence industry, arms exports, and military expenditure – is the most pertinent step to provide answers to these questions. Providing an overarching comparison of the three defence innovation systems will also contribute to the “national systems of innovation” (NSI) approach and fill an existing research gap, as outlined below. In order to facilitate the comparison, the thesis answers the following research question.

What are the similarities and differences between the defence innovation systems in China, Japan, and South Korea during the period from 1991 to 2021?

It is designed to enable a direct comparison from a top-down perspective. As outlined in sub-chapter 2.6, the defence sector is characterized by the central role of public agencies. Any analysis of innovation in the sector should therefore centre on its top-down management, specifically in light of the strong public role in defence industrial management in all three nations.

1.3. The Relevance of East Asian Defence Innovation Systems

The relevance of comparing the defence innovation systems of China, South Korea and Japan extends beyond a mere comparison of defence economic policy. The region is increasingly the centre of reignited great power competition and affected by bilateral conflicts centring on overlapping maritime claims. China on one side, and the United States and Japan on the other, have entered a geopolitical competition that also unfolds in a quest for defence technological leadership. The changing relationship of the United States to its East Asian allies emphasizes the need for independent domestic capabilities and thus boosts support for Japanese and South Korean defence industries alike (Steindl 2017).

These factors make a comparative analysis concerning the defence industrial capabilities of the major players within the region highly relevant. Established literature predominantly places a focus on the comparison of absolute military capabilities, as well as strategies and doctrines. Although these are intuitive and highly relevant approaches, an analysis of the underlying defence industrial schemes is even more pertinent. There are numerous case studies of respective national militaries and defence industries, but there is a research gap in respect of a structured comparison of defence innovation systems.

A comparative analysis of defence industrial capabilities allows the assessment and comparison of potential national innovation capacities, and thus the capability of nations to field more advanced defence systems and to compete for said defence technological leadership. As Western military interventions in the Middle East and former Yugoslavia have shown, the edge gained from such leadership can be both decisive for deterrence and in actual warfare. This lesson has also been understood by East Asian observers (Shambaugh 2002, 69–76).

The similarities and differences identified by this analysis can inform on how different economic structures and policy approaches impact defence innovation in East Asia. Furthermore, they allow conclusions in how far a coherent approach in East Asia exists, enabling a future comparison to those of EU, NATO and AUKUS (Australia, United Kingdom, United States) members.

It is practical to limit such a comparison to the most important defence innovation systems. Due to their sophisticated economies and size, in this regard three regional players stand out: China, Japan, and South Korea. Though the region encompasses other advanced defence economies, such as Singapore and Taiwan, the limited size of their defence industrial bases also reduces their relevance. Thus, a limitation of the study to the three nations named above is expedient.

As outlined in chapter 2, there is also a gap in the application of innovation system theory to the defence sector in general and specifically concerning comparative studies. This thesis thus also contributes to the national systems of innovation approach and its application to the defence sector.

1.4. Limitations

Studies on issues of defence are generally limited by the reluctance of governments to provide information and respective classification policies. This also applies to the defence industry and defence industrial policy. The thesis is thus limited by lacks in data availability, although the author strived for providing a comprehensive picture. Limited availability specifically concerns the period preceding 2000, as information policies have become less strict and access been eased.

Information policies are in general less strict in Japan and South Korea, and hence data and information can generally be sourced from original publications of respective governmental bodies. Chinese original sources, especially in English, are much more limited. The author has thus often reverted to secondary sources, bearing in mind the trustworthiness of researchers when choosing them.

2. The Theory of Innovation

2.1. General Definitions

The field of innovation research is characterized not only by a high number of specific terms, but also by their ambiguous utilization (Edquist 2005, 186–187). Thus, it is necessary to define some key terms beforehand, while subsequently additional terms will be defined in the scope of their theoretical introduction. The central term is innovation, for which definitions vary depending on the scope of the activities they encompass.

Swann (2009, 25) offers one of the more general definitions. According to him, innovation is “the successful exploitation of new ideas ... it is not just about the generation of new ideas, it is about their *commercial exploitation*”. While this definition already displays that innovation is much broader than simply research, it is too general for an analytical purpose.

Fagerberg (2014, 2) provides a double-fold definition. He states that innovation can be defined “as the overarching process from the appearance of new ideas to their economic application, or more narrowly only from the first creation of a new product, process, or *modus operandi*.”

Looking at innovation as result, instead of as a series of actions, Edquist (2005, 182) also takes reference to both product and process innovation. His definition is that “innovations are product innovations as well as process innovations. Product innovations are new – or better – material goods as well as new intangible services. Process innovations are new ways of producing goods and services. They may be technological or organizational.”

In respect to the difference of product and process innovations, Swann (2009, 28) states that rarely innovation can be separated in product or process innovation as “in practice, many if not most innovations embody some of each.” From the theoretical approach though, “a *pure process* innovation simply changes the way in which a product is made, without changing the product itself ... a *pure product* innovation ... creates a new or improved product for sale without any change in the production process – except that more inputs (labour, machine time and materials) may be required.”

The OECD/Eurostat (2018, 20) definition of innovation also considers the ambiguity of product and process innovations: “An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).”

Indeed, the definitions above do not contradict each other, as they only diverge in scope or depth. It is important to note though, all definitions state that innovation comprises of the whole process of invention to marketization and contains both the overlapping spheres of product and process innovation. The closely related term “invention” is defined as “the generation of new ideas, whether by research or other forms of creativity ... invention stops short of commercial use or exploitation” (Swann 2009, 25). Thus, invention is only one part of the larger process of innovation, or a preceding step, if innovation is defined as result.

Another in the innovation literature widely utilized term is R&D (research & development). Considering that the OECD was a forerunner in the analysis of science, technology and innovation policy, its Frascati Manual provides an authoritative definition: “Research and experimental development (R&D) comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge” (OECD 2015, 44). Furthermore, any R&D activity must be “novel, creative, uncertain, systematic, transferable and/or reproducible” (OECD 2015, 45).

R&D covers three activities: basic research, applied research, and experimental development. The Frascati Manual defines these activities as outlined below (OECD 2005, 45):

- „Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.“
- „Applied research is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective.“
- „Experimental development is systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes.“

These key terms, as defined above, bear relevance for the subsequent discussion of theoretical approaches to innovation and innovation policy.

2.2. The Classical Innovation Theory

2.2.1. General Assumptions

Although the modern form of innovation policy only emerged in the late 20th century, the concept of innovation in economic theory can be traced back to Adam Smith in 1776. Smith described innovation as a result of the division of labour and recognized it and the linked technological change as driving factors for “the wealth of nations”. Many important economists perceived innovation as central for economic development. Examples include John Stuart Mill, Karl Marx, and most importantly Joseph Schumpeter, whose concept of “creative destruction” presents the bedrock of contemporary innovation theory (Swann 2009, 7–22).

The classical approach assumes a simplified, linear model of innovation. It is based on the notion of a direct link between research and applicable technologies that would provide economic benefits, most notably development, but also boost national security (Kline and Rosenberg 1986, 285). The simplified model draws a straight line from basic research to large scale development in laboratories, and subsequent civilian and military application. Research into products and processes itself remains a black box in the classical theory (Chaminade and Edquist 2010, 97).

The model gained prominence through the Vannevar Bush Report, which built-upon the success of the Manhattan Project, and was henceforth established as the standard in the scope of technology policy. Subsequently, in 1963 it was standardized in the first version of what was later to be called the OECD’s Frascati Manual (Freeman and Soete 1997, 300).

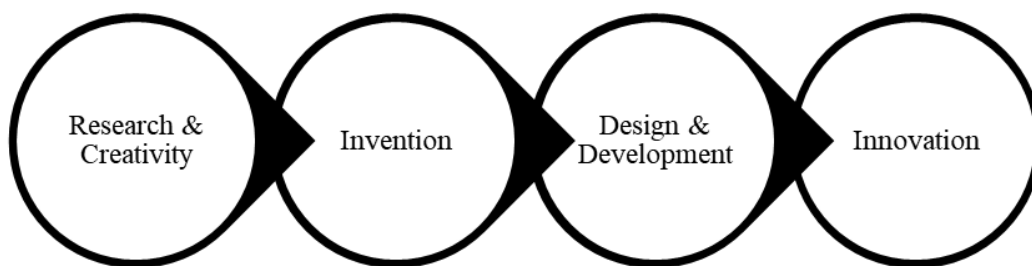


Figure 1 – The Linear Model of Innovation (Swann 2009, 23)

As shown below, this stands in contrast to the national systems of innovation approach that factors in the existence of collaboration and externalities, and thus sees innovation as process driven and steered by networks of actors, organizations and institutions. This emphasis of relationships means innovation cannot be captured in a linear process.

2.2.2. The Market Failure Rationale

The classic approach identifies market failure as the main rationale for public intervention. Market failure in this respect is defined as the failure of perfect competition within the free market economy (Swann 2009, 257–260).

The theory assumes that the properties inherent to the production and retainment of knowledge are the main drivers for market failure. The classical theory attributes knowledge three properties: Uncertainty, “inappropriability” and indivisibility. Uncertainty describes that the result, and specifically the risks of a research process, cannot be fully predicted. While this affects firm behaviour, the classical theory nonetheless still considers the invention process as linear and plannable. Inappropriability refers to the fact that firms can never fully retain the products of their research, which disincentivizes investments. Indivisibility on the other hand describes that for the creation of new knowledge some minimal expense is necessary, and thus investment is always needed (Chaminade and Edquist 2010, 97–98).

These three properties impede research and result in market failures that are related to economies of scale and externalities. On the one hand, the production and collection of information favours large scale undertakings, disfavours smaller firms. On the other hand, information can be copied at minimal marginal cost and thus innovative firms cannot retain the results of their own research.

Another problem arises from one of the intervention policies outlined below, property rights. These result in a “the winner takes it all situation”, where the first firm to register a patent gains all the benefits provided by an invention. These three reasons therefore lead to an assumed cost-benefit calculation that makes innovative undertakings unattractive for firms. Furthermore, society as a whole suffers from such market failures, as overarching positive externalities are reduced. Hence public intervention is necessary to ensure perfect competition in the market (Swann 2009, 260–266).

2.2.3. Forms of Government Intervention

The classic theory’s assumption of these market failures is utilized as justification for several general policy approaches. These include subsidies, institutions (laws), and direct government expenditure for R&D and procurement.

Subsidies may be employed to compensate for the negative externalities associated with research, thus mitigating the negative cost-benefit calculation for firms. Alternatively, subsidies may be utilized to encourage the adoption of new technologies, thus rewarding firms for the

positive externalities created through said adoption. Intervention through the creation of institutions on the other hand is primarily facilitated by the implementation of intellectual property rights (IPR). As outlined above, these in turn will not only support the emergence of monopolies and create a “the winner takes it all” situation, but also hamper technology diffusion. Thus, new problems are created by intellectual property rights.

Where serious cases of market failure occur, the government may also decide to conduct R&D internally. This is necessary where research is highly unprofitable but offers major positive externalities for society. Indeed, such ambitions suffer from the problem that the government often does not possess market-specific knowledge and incentives and should thus limit itself to basic research. This form of public intervention can also aggravate market failures, since it may crowd out private investment (Swann 2009, 267–270).

A more comprehensive discussion of policy approaches is presented in chapter 2.4.2., covering in depth the evolution of innovation and related policies.

2.2.4. Critique of the Classical Approach

Chaminade and Edquist (2010, 97–98) argue that the classical approach’s theory of market failure is, in general, too abstract to guide public intervention, as it does not inform where and to what extent public investment is suitable. Furthermore, it does ignore the dynamic role of institutions and hence single element solutions, such as intellectual property rights, create new problems that are not directly addressed. Therefore, while the instruments of classical innovation theory are relevant for overarching economic policies, they are not detailed enough to support the development of sectoral policies.

In light of these criticisms, the classical innovation theory has spawned two branches that partially take the critique into account. First, the “new economics of science and technology” focus on the role of technology as a public good and deduce that the rationale for state intervention in science is more convincing than in technology. Second, the “new growth theory” acknowledges that R&D is harder to plan than assumed by the original classical theory. It also recognizes the significance of information flows between actors and appreciates the central importance of innovation for economic growth.

Proponents of the national systems of innovation approach, linked to a larger field of evolutionary innovation theories, argue that these new offshoots of the classical theory nonetheless continue to suffer from major theoretical problems. These include that uncertainty of R&D is still much higher than assumed, and that the link between R&D and growth is too

simplified. Most importantly, the classical approach incorporates the assumption that an economic equilibrium can be achieved, which the NSI approach rejects (Chaminade and Edquist 2010, 99).

Already in the late 1980s and 1990s, research on innovation policy produced new insights that in turn impacted policy making, as outlined in the respective chapter below. These did not yet diverge from the general concepts of classical innovation theory. Boekholt (2010, 337–338) identifies three advancements impacting innovation policy, which he summarizes as the second generation of innovation policy, preceding a third one shaped by the NSI approach.

The first crucial advancement was the chain-linked innovation model, developed by Kline and Rosenberg (1986, 289–304). It amended the linear pipeline model that dominated policy discussions before. Central to this new model was the realization that innovation is not solely driven by the “technology-push” of research, but that it is also shaped by a demand-side “market-pull”. The chain-linked model thus integrated various feedback-loops that link research, the “corpus of scientific and technological knowledge”, and firm-internal innovation. It identified crucial links between public and private research in the knowledge production chain. This emphasis on links between different players in R&D provided an important impetus for the subsequent development of the NSI approach.

The second insight was provided by von Hippel (1988, 102–116), whose analysis of user-producer interactions led to the characterization of lead users and early adopters that have an important impact on emerging consumption patterns. For example, Fagerberg (2014, 6–8) has analysed extensive surveys on the perception of European firms on innovation, which have confirmed that external clients, customers and suppliers are both an important source of information and for innovation cooperation. While the classical theory assumes lacking diffusion of information as a market failure, it overlooks the problem that some forms of knowledge are too “sticky” (von Hippel 1994, 437–438).

The aforementioned surveys showed that companies rank lead-time and secrecy as the most important factors for retaining knowledge, attributing to them more importance than to trademarks and product complexity. Hence on the firm level, competitiveness presents a bigger issue than the retention of information. Though limited information and uncertainty may indeed prevent investments in innovation, the underlying reasons are not addressed by the traditional model (Fagerberg 2014, 5).

The third, and for policy making eventually one of the most crucial insights, was provided by Porter’s (1990) research on the role of clusters and value chains. It also aligned with the

emerging NSI approach and emphasized the relevance of networks and agglomerations. His research highlighted the spatial aspect of networks and had a significant impact on regional development and technology transfer policies.

2.3. The National Systems of Innovation Approach

2.3.1. Theoretical Differences to the Classical Approach

The previous discussion on the critique of the classical theory has already outlined the main differences between the classical theory and the national systems of innovation approach. Crucial differences are the assumed models of the innovation process, market failures, and the existence of an economic equilibrium in the scope of innovation. Chaminade and Edquist (2010) provide a brief overview of the theoretical divergences, displayed in Table 1.

Table 1 – Theoretical Differences between the Classical Innovation Theory and the NSI Approach (adapted from Chaminade and Edquist 2010, 101)

	Classical Theory	NSI Approach
Underlying Assumption	Equilibrium Perfect Information	Non-equilibrium Asymmetric information
Focus	Allocation of resources for invention Individuals	Interaction in innovation processes Networks and framework conditions
Main rationale	Market failure	Systemic problems
Main policy	Science policy (research focus)	Innovation policy (overarching)
Government Intervention	Provision of public goods Mitigation of externalities Reduction of market entry barriers Elimination of inefficient market structures	Solutions to system problems Facilitation of the emergence of new systems Inducement of changes in the supporting system structure (Support of the creation and development of institutions, organizations, networks) Facilitation of transitions and avoidance of lock-ins

2.3.2. The Static Approach and Components of the System

The national systems of innovation (NSI) approach has continuously been developed since its conception and went through three specific stages of development. In order to understand the current state of the approach and identify the analytical scope the NSI approach, its elements are introduced along a brief outline of this historical evolution. Researchers both utilize the terms “national systems of innovation” or just “systems of innovation”, with the latter considering that the approach is also applicable for the analysis of sectors or regional innovation

systems. The approach is referred to as “NSI approach”, although it is not strictly limited to the analysis of national, but also sectoral and geographical sub-systems.

The term “national systems of innovation” was first introduced by Freeman (1987, 1), who defined it as “the network of institutions in the public and private sectors whose activities and interactions initiate, import and diffuse new technologies”. The research angle that has been formalized by the NSI approach can be traced as far back as to Friedrich List’s work in the 19th century, who already identified the main actors of an NSI.

He defined educational-, training-, science-, and technology-organizations, user-produced learning, knowledge accumulation, adaption of important technologies, and support of strategic industries as the central factors for innovation on the national level. Indeed, his work on innovation was a major factor for establishing an advanced education system in Germany, specifically Prussia, which the German economy’s catching-up and later over-taking of the British one is attributed to (Freeman and Soete 1997, 295-299).

The NSI framework as analytical tool was developed in the early 1990s, and first employed in the ground laying works of Lundvall (1992) and Nelson (1993). Influenced by the Schumpeterian theory of creative destruction, Lundvall and his co-authors developed a systemic approach for assessing innovation and the knowledge economy in a national context. The authors provide two definitions for the NSI.

According to the first, narrow one, an NSI comprises of “organisations and institutions involved in search and exploring”. Following the second, even broader one, an NSI includes “all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring”. Hence the latter one covers production, marketing and finance systems, as well as other sub-systems in which learning plays a role (Lundvall 1992, 13).

The objective of Lundvall and his colleagues was to enable cross-country comparisons and to assess the varying impact of globalization on innovation in nation states. Thus, five levels of the NSI were identified for analysis: the internal organization of firms, inter-firm relationships, the role of the public sector, the institutional set-up of the financial sector, and R&D-intensity and -organization (Lundvall 2002, 14).

This rather broad concept became subsequently known as the “Aalborg concept of national systems of innovation” and was further developed by Lundvall and his team. Summarized, according to Lundvall “...the innovation process is neither fully automatic ... nor fully deliberate. The innovation process reflects ... initiative and creativity, but is also deeply

influenced by production activities and institutional setting.” (Lundvall 2002, 221). While the Aalborg concept was extended, Lundvall deliberately opted to keep the approach as open as possible, in order to provide a picture of the NSI that is as comprehensive as possible (Lundvall 2002, 221).

The second founding work in the field of innovation systems by Nelson (1993), was directly comparing 15 free market, high-income economies in Europe and Asia. Nelson utilized a more limited definition for the NSI that nonetheless does not include a specific framework. He defined innovation as “...the processes by which firms master and get into practice product designs and manufacturing processes that are new...”, while an innovation system “...is that of a set of institutional actors that, together, plays the major role in influencing innovative performance.” (Nelson 1993, 4–5).

Contrary to Lundvall, whose work specifically focused on the national character of said systems, Nelson’s aim was to assess in how far the notion of a national system of innovation has relevance in the modern globalized world. Despite the differing departure points, both Lundvall and Nelson came to the conclusion that the NSI is a viable concept, in which international knowledge transfers are but only one factor. The new NSI approach quickly proliferated and spawned new research directions, analysing technological, sectoral and regional innovation systems. These more focused approaches were henceforth integrated in the generic NSI approach (Edquist 2005, 183–184).

Another early contributor to the approach, Edquist, defined a system of innovation as comprising of “the determinants of innovation processes ... all important economic, social, political, organizational, institutional, and other factors that influence the development, diffusion, and use of innovations” (Edquist 2005, 182). The elements of such a system are thus “components + relations among the components” and the “main components (are) organizations and institutions” (Edquist 2005, 182).

Components of the System

The first element, organizations, “are formal structures that are consciously created and have an explicit purpose” (Edquist and Johnson 1997, 46–47) and present the players and actors in the system. These include universities, venture-capital organizations and public bodies steering and implementing innovation policies.

The second element are institutions, which are established legally or customarily, and reduce both choices and uncertainty. They are a crucial tool to influence economic behaviour. This

characterisation of institutions was guided by Scott's parallel research on institutions and organizations (Kuhlmann, Shapira and Smits 2010, 11).

Scott (2014, 60) distinguishes three types of institutions. The first, regulative institutions, are utility-oriented rules that are enforced by coercion. The second, normative institutions, are norm-based social obligations that are binding through expectation. The third, cultural-cognitive institutions, are models of reality that are taken for granted. While Scott's typology illustrates the breadth of institutions that have an impact on innovation systems, its comprehensiveness makes an analytical application hardly feasible. In a more limited form, Edquist and Johnson (1996, 46) define institutions as the "common habits, norms, routines, established practices, rules, or laws that regulate the relations and interactions between individuals, groups and organizations" (Edquist and Johnson 1997, 46).

Furthermore, an NSI has "a function i.e. it is performing or achieving something. The main function ... is to pursue innovation processes, i.e. to develop, diffuse and use innovations" and "Activities ... are those factors that influence the development, diffusion, and use of innovations. The activities ... are the same as the determinants of the main function" (Edquist 2005, 182).

Edquist (1997) furthermore criticised the early approach of the NSI. In his opinion, it applied a static, descriptive approach that focused on central actors and their relationship, while disregarding dynamics that play out over time. As Fagerberg (2014, 9) later agreed, the results of such snapshots were of limited utility for policy making, specifically since they ignored the respective historical development of a specific NSI. Thus, both further adapted the NSI approach to make it more applicable as an analytical tool. The central elements of the NSI introduced under the static approach nevertheless remain at the core of the NSI framework.

2.3.3. The Process Approach and Failures in the System

The next major advancement in the research of national innovation systems was thus undertaken by Edquist (1997), though other researchers contributed to the process. He criticised that, due to its broadness, the concept of the NSI as developed by Lundvall and Nelson was rather an approach than a formal theory (Edquist 2004, 486). Specifically, the lack of a systemization of functions and activities occurring in the system presented a research gap. Furthermore, he dismissed the deterministic approach of the two author groups who intended to identify factors that drive innovation processes in general. Since innovation systems are determined by separate national histories of evolution, there is no such thing as "optimality" in the innovation system.

On the other hand, Edquist also acknowledged that comparative studies hold value to identify the success of some NSI and the failure of others. The lessons learned from comparative research do not allow the development of a general “successful” approach that could be utilized for establishing an overarching policy tool though. Thus, a narrower concept is valuable for policy making, but the attempt to steer innovation systems from a central position defeats the purpose of enabling innovation (Edquist 2004, 486–87).

Activities in System

Moving onward from his critique of the static approach, Edquist developed said narrower concept of the NSI. In order to overcome the original rigid approach, focusing solely on organizations and institutions (laws and norms), he identified activity in the system as the real driver of the system (Edquist 2011, 1727). He thus recognized the argument of Liu and White, who criticised the “the lack of system-level explanatory factors”, as researchers primarily have focused on the performance of specific actors rather than the system-level influence of institutions and policies (Liu and White 2001, 1092; Edquist 2005, 189).

Likewise, Bergek et al. (2010, 121) argue that the research focus ought to be on processes and phases, rather than fixed states. This enables conclusions on the dynamics of the system and can thus inform policy making. For that purpose, the authors define two levels of analysis. The first comprises of actors, institutions and networks. Research should focus on the entry of actors into the system, the adaption or retention of institutions, and the formation of networks. The second level on the other hand covers the general functions of the system, which are the generation, diffusion, and utilization of technology.

Liu and White (2001, 1094) extracted a list of five fundamental activities from the previous literature on NSI systems, developing a framework for their analysis of the Chinese innovation system:

- research (basic, developmental, engineering);
- implementation (manufacturing);
- end-use (customers of the product or process outputs);
- linkage (bringing together complementary knowledge);
- and education.

Similarly, Bergek and Jacobsson (2003, 199) also proposed a list of five NSI functions, which they utilized for a comparison of wind turbine industries:

- to create „new knowledge“, which is also a general objective of an NSI;
- to guide the direction of the research process of suppliers and customers;
- to provide resources, e.g. capital, know-how, etc.;
- to assist in the formation of positive externalities;
- and to assist in the emergence of new markets.

Another more comprehensive list of factors with importance for technology-based firms, therefor developed from a bottom-up view, is provided by Rickne (2000, 175, quoted in Edquist 2005, 189):

1. create human capital;
2. create and diffuse technological opportunities;
3. create and diffuse products;
4. incubate (provision of facilities, equipment, administrative support);
5. facilitate regulation that may enlarge the market and facilitate market access;
6. legitimize technology and firms;
7. create markets and diffuse market knowledge;
8. enhance networking;
9. direct technology, market and partner search;
10. facilitate financing;
11. and create a labour market that the new technology-based firms can utilize.

The divergence of the lists presented above displays the criticised lack of a coherent framework for the functions of an NSI. For the purpose of utility, researchers tend to develop their indicators at hand of a specific research project, rather than from a generic theoretical perspective. This lack of specific functions is both a strength, as it makes the framework adaptable, and a weakness, as it reduces comparability.

Specifically citing the three lists above, Edquist (2005, 190–191) undertook the development of a generic “activity” list. He defined the general, overall system function as the pursuance of innovative processes (development, diffusion, and utilization if innovation). Important system “activities” are those processes that affect this function.

Edquist (2011, 6–7) subsequently ordered these main activities into four categories.

1. Provision of knowledge inputs to the innovation process
 - a. Provision of R&D
 - b. Competence building
2. Demand-side activities
 - a. Formation of new product markets
 - b. Articulation of quality requirements
3. Provision of constituents for the NSIs
 - a. Creation and change of organisations
 - b. Interactive learning, networking, and knowledge integration
 - c. Creation and change of institutions
4. Support services for innovating firms
 - a. Incubation
 - b. Financing
 - c. Consultancy services

For the narrower field of technological innovation systems, Bergek et al. (2010, 121) define seven functions that are necessary for the correct functioning of the system:

1. knowledge development and diffusion;
2. influence on the direction of search and the direction of opportunities;
3. entrepreneurial experimentation and management of risk and uncertainty;
4. market formation;
5. resource mobilization;
6. legitimation;
7. and the development of positive externalities.

While these seven functions mostly align with Edquist's list, there are discrepancies due to Bergek et al.'s adaption of the framework for specific technology systems. The latter authors have designed their list specifically in the context of innovation policy making. On the level of technology systems (i.e., the systems of innovation for specific technologies), the legitimation of new technologies is crucial for acceptance by the market. Furthermore, Edquist does not mention positive externalities as a function that is important for the actual functioning of the system.

As the three types of learning outlined below display, activities cannot be directly linked to specific organizations. Likewise, institutions cannot be linked to certain organizations either.

Thus, the main activities take place throughout the system. Processes in the NSI are always multi-causal and any analysis is never fully complete. Though it is not possible to directly define the determinants of innovation, it is important to conceive theories about the links between certain variables (Edquist 2005, 190). The delimitation of a system of innovation is always arbitrary. It can be delimited along geographical or spatial factors, sectoral ones, or by focusing on specific activities (Edquist 2005, 199).

Innovation Systems and the Concept of Learning

Learning, which stands at the centre of any NSI's function, can be split into four types. The first one is innovation (in new products and processes), which occurs primarily in companies, and results in "structural capital" that is owned by firms. The second one, research and development (R&D), occurs in universities and public research bodies and results in the creation of public knowledge. It can also take place in firms themselves and is owned by said organizations or individuals. The third and last, competence building, occurs in educational facilities such as schools and universities, but also in firms, and results in the creation of human capital. It is centred on the training and education of individuals (Edquist 2005, 192).

The generation of any kind of knowledge depends on the process of active learning. Specifically focusing on technological knowledge, Bergek et al. (2010, 117–122) state that it takes shape in the form of "distributed knowledge bases". These can be found in a highly specific form in firms, codified in disciplines in industrial sectors, and in its general scientific forms. Research on innovation systems has shown that these knowledge bases are characterized by high levels of interdependence and blurred borderlines. The high complexity of modern technologies also impedes firms from developing all relevant knowledge. Thus, cooperation and collaboration between actors in the system have a crucial role in the functioning of the system. This stands in contrast to the classical theory's assumption of a high level of firm independence.

Path-Dependency and Lock-ins

Path-dependency, the assumption that current economic outcomes as well as choices depend on previous events, plays both a positive and negative role in the NSI (Puffert 2019). In its positive form, path-dependence is the driver of self-replicating specialization in technological fields. Specialization is a central component in the system-building of emerging technologies, and one condition for competitive advantage. If successful, specialization leads to increasing returns and thus has again a path-dependence inducing effect (Bergek et al. 2010, 117-118).

On the other hand, path-dependency and established strong technological regimes may create a lock-in into old technologies. A lock-in, in other words a stable configuration, refers to the state of a system in which it ceases to develop (Fagerberg 2005, 13). This can impede the emergence of new markets and the transition to emerging technologies, thus hindering the very function of an NSI (Chaminade and Edquist 2010, 103). Path-dependency does not only occur in specific technologies and technology fields, but also affects social, political and institutional processes (Edler and Fagerberg 2017, 10).

System failures

Failures in the innovation system may take various forms that go beyond lock-ins. In their framework on innovation system failures, Woolthuis, Lankhuize, and Gilsing (2005, 612–614) define four types of system failures:

1. infrastructural failures (related to actors and organizations);
2. institutional failures (of laws and regulations);
3. interaction failures (in or due to the lack of networks);
4. and capability failures (by actors).

Chaminade and Edquist (2010, 102–104) provide a similar, but extended list of failures:

1. infrastructure and investment problems;
2. transition problems (as a result of high uncertainty during paradigm changes);
3. lock-in problems (as a result of socio-technological inertia and strong technical systems);
4. hard- and soft-institutional problems;
5. network problems (lack of information on dynamics outside of the network, as a result of too strong internal or too weak external links);
6. capability and learning problems (as a result of lacking human capital or management issues);
7. unbalanced exploration or exploitation mechanisms (as a result of missing selection mechanisms, or insufficient diversity);
8. and complementary problems (if the system lacks complementarity or the capacity to utilize complementary capabilities).

The strength of this extension to the NSI framework, by splitting it into components and functions, is the potential of a functional analysis (Bergek et al. 2010, 130). This allows the

drawing of conclusions necessary for policy making to prevent or mitigate the potential system failures listed above.

2.3.4. The Synthetic Approach and Policy in the System

In reference to the process focused NSI framework, Fagerberg (2014) has developed an even more comprehensive framework that brings together the central NSI components, functions, dynamics over time, and policies. He argues that neither the static approach of the 1990's descriptive NSI studies, nor the solely process oriented approach, capture all aspects of the innovation system. Fagerberg's "synthetic approach" emphasizes the integration of mission-oriented innovation policies into the NSI framework (Fagerberg 2014, 3).

Mission-oriented policies are centrally planned, clearly outlined policies with a focus on a specific technology or demand. In the defence sector, especially the US, the UK and France have concentrated on mission-oriented R&D policies (Ergas 1987, 193–194). Fagerberg also addresses and defines the output of the innovation system as "technological dynamics", comprising of innovation, diffusion and the use of technology. Foreign influences have an impact on these technological dynamics as well (Fagerberg 2014, 10).

He defines five distinct processes that drive an NSI: knowledge, skills, demand, finance, and institutions. While knowledge is provided by public R&D organizations, such as universities, skills can both be specialized and general, and are located within companies. Demand describes the overall demand for innovation, and finance covers both financing and taxation. Institutions on the other hand comprise of laws and regulations enabling or limiting innovation. The public hand can manage the NSI by adjusting these processes (Fagerberg 2014, 11–12).

The addition of a specific "government layer" is based upon the work of Smits and Kuhlmann (2004) on "systemic instruments". Already under the influence of Edquist's process focused approach, and the increasing impact of the NSI concept on policy making, Smits and Kuhlmann (2014, 12) identified "systemic instruments" that are used to influence the NSI's activities. Such instruments are utilized to:

- manage interfaces (across sectors);
- build and organize innovation systems;
- provide platforms for learning and experimenting;
- provide infrastructure for strategic intelligence (e.g. technology foresight);
- and stimulate demand, strategy, and visionary development.

According to Fagerberg, these steering instruments can be linked to specific public agencies, which may vary between countries and are hence described with generic names. Knowledge falls under the responsibility of the Ministry of Research, skills under those of the Ministry of Education and sometimes Industry, with the latter also bearing responsibility for policies aimed at boosting demand. Additionally, the Ministries of Defence, Energy, Environment, and Health can utilize procurement for boosting the demand for innovation. The finance process on the other hand is both driven by the Ministries of Industry and Development, though the Ministry of Finance has the authority on taxation. Institutions on the other hand may fall under the authority of the Ministry of Justice and the government as a whole (Fagerberg 2014, 11–12).

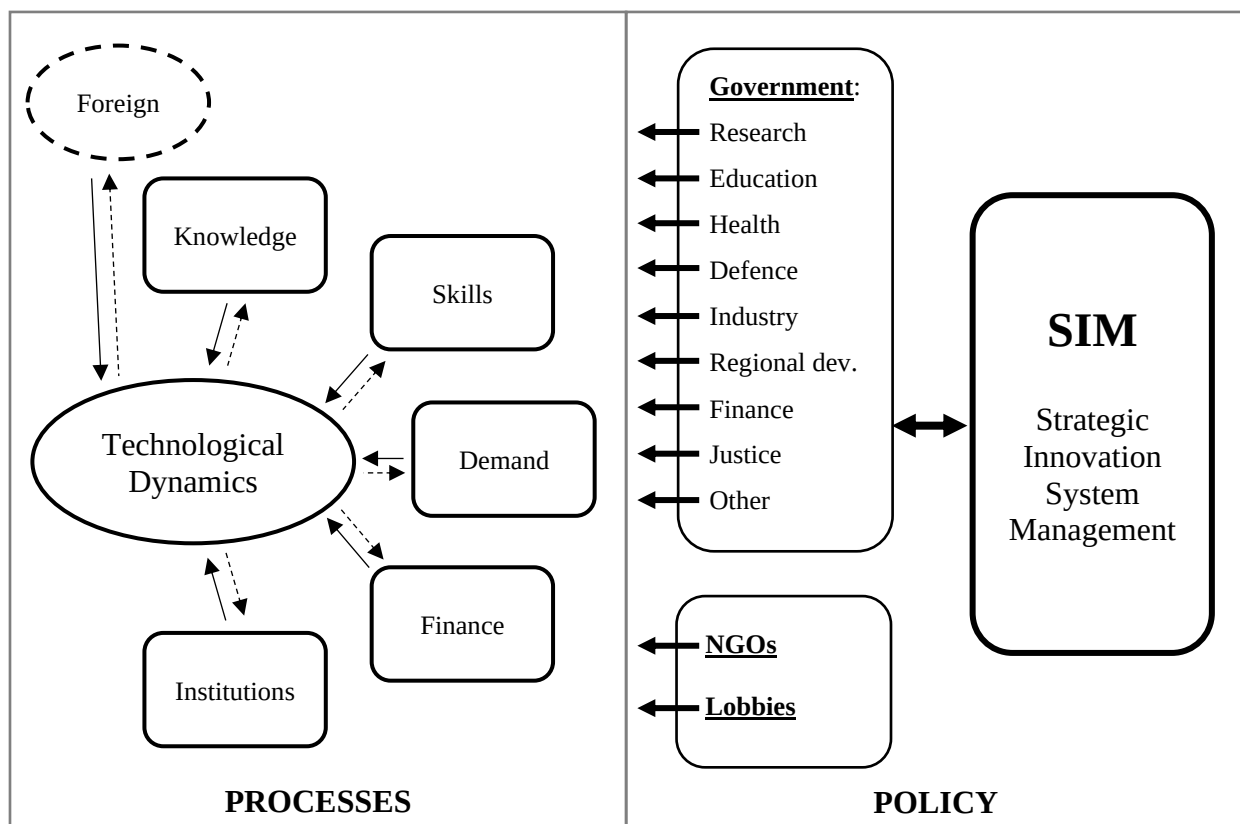


Figure 2 – Fagerberg’s visualization of the innovation system (adapted from 2014, 11)

Underpinning the sectoral policies implemented by ministries as “processes” is the “strategic innovation system management” (SIM), as introduced by Smits and Kuhlman (2004). A few countries have developed centralized innovation agencies to coordinate this management, first and foremost Scandinavian countries since the early 2000s. Despite this, Fagerberg acknowledges that different sectors require distinct innovation policies, due to varying dynamics. Furthermore, due to the unique, historically evolved industrial economies, each country has different shortcomings, priorities, and in the end goals. Nonetheless, the defined

five processes are essential for any innovation system, since the lack of only one of them can gridlock the whole system (Fagerberg 2014, 12–16).

In this context, Fagerberg's crucial contribution to the NSI approach is the formalization of the policy formulation and implementation within the framework, by integrating Smits and Kuhlmann's strategic innovation system management. This is indeed not a dramatic shift from the previous approach, as the "organisations" component in fact covered this aspect. Nonetheless he provides a more formalized framework for analysis that separates the public and private spheres and establishes policy as a separate layer.

2.3.5. Strengths and Weaknesses of the NSI Approach

The NSI approach has developed along the three major phases outlined above. Nonetheless these adaptations of the approach have not rendered preceding ones obsolete. Lundvall (2016, 101–103), one of the first researchers in the field, for example integrates Edquist's insights in his later writings. On the other hand, he mentions the approaches of List, Freeman, and Nelson as alternative approaches. While he does not mention Fagerberg, he also references Michael Porter's work on clusters as a de facto NSI approach.

The NSI approach as analytical tool offers both strengths and weaknesses. Edquist (2005, 184–186) provides a comprehensive outline of these, which are in general valid for the variations of the approach. According to him, there are five major strengths:

- it is holistic, as it integrates organizational, social, political, and economical factors;
- it covers a historical and evolutionary perspective that recognizes the dynamic of the system, while it does not focus on a misguided notion of optimality;
- it takes into account the interdependence and non-linearity of the innovation process;
- it covers both product and process innovation;
- and it emphasizes the important role of institutions.

On the other hand, he also identifies three important weaknesses that are prevalent in the utilization of the NSI as analytical tool:

- „institutions“, despite being a strength of the framework, suffer from a conceptual vagueness, since different authors both utilize the term for organizations and actors, and laws and regulations;
- the founders of the approach did not specify the boundaries of the NSI approach, reducing the comparability of case studies;

- and the NSI remains an approach / conceptual framework and has never been developed into a formal theory.

The last two weaknesses refer to a deliberate decision though, as Lundvall himself argued that the NSI should remain just an approach and open framework, rather than a theory, to enable a more flexible application for different countries (Lundvall et al. 2002, 221).

Considering the application of the NSI approach for policy making, Chaminade and Edquist (2010, 104) also identify several gaps between the theory of the NSI and how it operates. These include:

1. the framework is too static and cannot explain the consequences of policies;
2. there is a lack of research on the links between the systemic level and the micro-level (e.g. firms);
3. and the discussion on respective policies has not sufficiently focused on the issues of uncertainty, selectivity and path dependency.

Chaminade and Edquist (2010) specifically pay attention to the last of these research gaps, as outlined in the following sub-chapter. Furthermore, the research on relevant policies shows that the application of the NSI approach for actual policy making suffers from some ambiguity, not least because of the continued relevance of classical policy tools in the application by governments. Hence for now, the strength of the NSI approach appears to lie in its role as an analytical framework. Nonetheless in light of this thesis's research ambition, a closer look on policy making is necessary. Therefore, the next chapter deals with this element separately, in context of the broader field of relevant policies.

2.4. Innovation Policy

2.4.1. Defining Innovation Policy

Innovation policy stands at the centre of the discussions on innovation and constitutes the main component of the strategic innovation management system. Hence a separate chapter is necessary to assess the theoretical state of the art on this issue. Since the term innovation policy is often utilized in an ambiguous manner, as a first step it needs to be defined. Subsequently the evolution of innovation policy and its related policy fields is assessed, as well as its conceptualization in the NSI approach.

Policy in general can be defined as “a purposive course of action followed by an actor or set of actors in dealing with a matter of concern. Public policies are those developed by governmental bodies and officials” (Anderson 2014, 7). Definitions of innovation policy itself vary in their

comprehensiveness, due to differing understandings of innovation itself. For example, a broader approach may include all those policies that actually affect innovation. In contrast to that, a narrow approach of innovation policy may only consider those policies specifically designed to influence innovation (Fagerberg 2014, 2).

Indeed, the majority of researchers of the topic, specifically those that have adopted the NSI framework, propose a broad approach for the definition of innovation policy. If only policies with the term “innovation” would be considered for the analysis of innovation policy, this would not only restrict research to a few high-income economies, but actually overlook many policy mechanisms that have an important impact on innovation (Edler and Fagerberg 2017, 3–4).

For example, in a study for the European Commission, Cowan and van de Paal (2000, 9) define innovation policy as “a set of policy actions to raise the quantity and efficiency of innovative activities, whereby ‘innovative activities’ refer to the creation, adaption and adoption of new or improved products, processes or services.” Likewise, Chaminade and Edquist (2010, 95) utilize a broad definition: Innovation policy comprises of “the public actions that influence innovation, processes, i.e. the development and diffusion of (product and process) innovations”. Likewise, Boekholt (2010, 334) states that “innovation policy refers to policies stimulating the translation of knowledge into new commercial applications.” The theoretical definition of innovation policy is in fact systemic and covers “a system-wide distribution of varieties of innovation-related policies across domains [as well as] policies working on systemic characteristics” (Kuhlmann, Shapira, and Smits 2010, 5).

Boekholt (2010, 334) proposes the term “RTDI-policy” (research, technology, development, innovation) as an overarching, capture-all term for policies targeting the innovation system. The adoption of the broad definition likewise entails that innovation policy becomes a capture-all term for all major policy types affecting innovation, as defined at the beginning of the chapter. Thus, there is a crucial difference between the utilization of “innovation policy” for the purpose of analytical research, and its utilization in the sphere of public policy formulation.

Considering the historic evolution of respective policymaking, as outlined in the next sub-chapter, public science, technology and innovation policies present the three core elements of the broader field of innovation policy research. Considering the number of public policy types that are introduced below, a preliminary definition of the core terms is necessary. Boekholt, in his synoptic view on the evolution of innovation paradigms, summarizes the differences of the policies as outlined below.

The UK Royal Society (quoted by Boekholt 2010, 334) provides a comprehensive definition of science policy, which is drawn on by researchers focusing on STI-policies. The definition states that “science policy deals with policy for science (covering issues such as funding of university research, intellectual property rights for scientific research and education policy) and public policy issues with a scientific aspect”. In contrast to that “technology policy is a specific aspect of research policy, which is restricted to policies aiming at the enhancement of technological improvement, often excluding organisational and other non-technological changes.” Furthermore, “research (and development) policy includes the activities of private sector research performers, particularly when development activities are included.” (Boekholt 2010, 334)

Both in research and by public policy makers, the respective terms are utilized in an arbitrary fashion, often in the context of national cultures, and the integration of research and innovation policies varies from nation to nation (Boekholt 2010, 334). The emergence of the three core elements, abbreviated as STI-policies, occurred in the framework of the classical innovation theory and they were later integrated in the NSI framework. The theoretical discussion of the relevant policies is provided in a historical outline in the sub-chapter below.

2.4.2. The Evolution of STI-Policies

Though innovation policy has received increased attention from the policy angle due to the „national systems of innovation“ approach, innovation itself has in its various forms played an important role in history. One of the earliest examples for a defined governmental policy targeting specific technologies was a cannon acquisition programme in 16th century England.

Under Henry VIII, England implemented a programme for acquiring sophisticated, but affordable, bronze cannons for its war against France. Under this policy framework, strategies such as public procurement, property rights, competition policy, export licencing and most importantly the encouragement of immigration by skilled labourers from continental Europe were utilized. Its sophistication therefore mirrors modern innovation policies in the defence sector (Yakushiji 1986, quoted in Lundvall and Borrás 2005, 600).

Only the mid-20th century saw the emergence of coherent science and technology policies, primarily in the US and Europe, which would shape similar approaches abroad. Though technological advantage played a crucial role in economic development and warfare even before, the lessons gained during the 2nd World War underscored the importance of strategic science and technology policies. The success of the Manhattan Project, with its aim of developing the first atomic bomb, underscored the view that any problem could be overcome

by promoting specific technologies. While both Henry VIII's cannon acquisition programme and the Manhattan Project built on the recruitment of scientists from abroad, a feature of science policy, by its nature these undertakings are examples for dedicated technology policies.

The growing geopolitical competition of the emerging Cold War and the USSR's head start in the space race boosted the relevance of a strategic science and technology policy for the Western countries. Although science policy was already a feature of planned economies, the Vannevar Bush Report, "Science: The Endless Frontier" of 1945, shaped by the lessons of the Manhattan Project, brought it on the agenda of the US government. Akin to Bush, the work of the British John Desmond Bernal on the relationship between science and society, and his publication "The Social Function of Science" in 1939 is recognized as pioneering work for modern science policy. Both reports defined science policy as crucial tool for economic growth and national defence and called for increased public spending on science (Lundvall and Borrás 2005, 601–605).

Science policy is concerned with the provision and distribution of resources for universities, research institutes and laboratories. The education and recruitment of students and researchers, and the links between science, government, and industry are at its centre. The policy type primarily falls under the authority of ministries tasked with education and research, and related councils. Nonetheless, due to the broadness of science undertakings in society, sectoral ministries are also involved, such as in defence, energy, transport, environment or health.

Technology policy, on the other hand, is concerned with specific technologies or sectors that hold strategic value, such as the space and nuclear industries, medicine, computer and genetic engineering. These are attributed with increased innovativeness and economic growth opportunities, thus meriting public support. Such sectors and respective policies vary between countries, specifically due to differences in their economic development. They are often linked to national defence, and the social and political advantages associated with technological leadership. While closely linked to science policy, technology policy places more emphasis on the relationship between industry and academic research, specifically in the frame of engineering. Sectoral ministries have thus more relevance, as more targeted policy instruments fall under their authority (Lundvall and Borrás 2005, 604–611).

The post-war period's emerging science and technological policies were shaped by the previously described linear-model, which assumed a straightforward research and development process with little uncertainty. The model also assumed a one-directional pipeline model, according to which the market would accept any products of the research process and established a top-down steering role for the government. The focus of public policy was

therefore on subsidizing basic and applied research in existing research centres, and on enabling large-scale, strategic research projects with a clear mission-oriented focus.

This led to the rise of large firms and agglomerates that dominated strategic sectors, and the creation of and support for major institutions such as the US Federal Laboratory System, the German Fraunhofer Society and the Dutch TNO. Leading universities like the MIT and Stanford, and prominent clusters such as the Boston Route 128 Corridor and Silicon Valley developed due to the profitability of massive governmental projects (Boekholt 2010, 335–337).

Beginning in the 1990s, the emergence of the chain-linked model, with its interactive feedback loops, user-producer interactions, and most importantly the insights on clusters and value chains transformed RTDI-policy. It took, despite that, two decades before the notion of linear innovation was overcome, although the classical model still has its role in debates. Policy making was adapted to integrate new approaches that transcend the scope of the former pipeline model.

New dynamics in the US influenced policymaking in Europe first and subsequently globally. The emergence of smaller, so called new-technology-based firms (NTBFs) and their high growth rates were an impetus to new forms of policy. The discussion on NTBFs brought attention to small- and medium enterprises (SMEs). In the US, these thrived due to the availability of risk-taking seed and venture capital, and the links between leading universities and the private sector. Thus, public grant, subsidy, and tax incentive schemes for risk-mitigation and co-funding of R&D became mainstream in Western RTDI-policy.

New policy tools to facilitate technology transfers, expand links between NTBFs and universities, and incentivize seed and venture capital were developed. Furthermore, regional governments established intermediary organizations to support SMEs, and the creation of science parks and university liaison-offices was encouraged. This expansion of policies was paralleled by a theoretical debate between proponents favouring market forces to select research foci, and those favouring the public support for existing and potential pockets of strength (Boekholt 2010, 338–340).

Another theoretical discussion on the “absorptive capacity” of firms likewise led to the emergence of dissemination policies. “Absorptive capacity” is defined as “the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends” (Cohen and Levinthal 1990, 128). The policy discussion on absorptive capacity led to some countries focusing on mission-oriented policies, while others preferred to favour diffusion-oriented ones. This divergence was also driven by the fact that absorptive capacity

has been widely treated as a “black-box”, and thus it provides no indicator for the amount a single firm should invest to improve it (Boekholt 2010, 341–342).

Arnold et al. (2005, 12–17) identify five elements that bear relevance in the scope of absorptive capacity: Human capital (specifically skilled labour), networking capacity (with external knowledge sources), organisation, routines, and organisational capacity, firm internal learning processes, as well as codification of tacit knowledge. Policies shaped by this discussion on absorptive capacity incorporate a specific focus on SMEs as well. These encompass innovation management and coaching programmes, mobility programmes for employees and students, consultancy by innovation agencies and technological centres, as well as the aforementioned R&D co-finance subsidies and grants (Boekholt 2010, 342).

The emerging innovation systems approach did not dramatically change the portfolio of existing and emerging policies but provided a new framework for their implementation. On the one hand, the NSI shifted attention from the classical argument of market failure to systems failures, and on the other hand provided the analytical tool to identify those. In the European context specifically, policies were implemented in the nature of “bridging” mechanisms in order to fix inconsistencies between system components.

Although grants and subsidies still play a central role in these endeavours, attention shifted to collaborative undertakings that incentivize different actors in the system to work together. This adaption was also driven by the insights provided by the aforementioned research on the advantages of clusters. As the NSI approach predicts, NSIs are unique in regard of their historical evolution, and policy approaches vary as well. Some countries such as the UK and the Netherlands have abolished grants altogether, and likewise funding by the European Commission is slowly shifting from subsidies to financial incentives gained from tax deductions (Boekholt 2010, 344-346).

Several innovation researchers have labelled a currently evolving overarching approach as the “third generation” of innovation policy, which places it at the centre of all policy fields. Boekholt (2010, 351-353), who provides one of the most comprehensive discussions on the history of innovation policy, argues though that after the linear, chain-linked and NSI approaches this is indeed already the “fourth generation”.

Shifting from the previous form of developing specific policy answers, the new approach is characterized by a “policy-mix” debate aimed at developing policy portfolios. In this context a “policy-mix” is defined as “the combination of policy instruments, which interact to influence

the quantity and quality of R&D investments in public and private sectors” (Boekholt 2010, 353).

The new overarching approach in innovation policy is driven by a number of factors, such as globalization and related competition, and the rising relevance of grand challenges such as climate change. This in turn creates an increasing demand for respective solutions based on multidisciplinary research. The overarching issues require a form of governance that encompasses actors from outside the traditional field of RTDI-policy and integrates both the innovation system and other policy fields. Growing attention is given to additional elements, such as competition and fiscal policies, and general education and macro-economic policies, which also impact an economy’s innovativeness. Boekholt (2010, 352) thus defines three forms of horizontal co-ordination bearing relevance for the new holistic approach:

1. the coordination of various societal and economic goals with RTDI-policy;
2. the further integration of the knowledge-creation chain and its different actors;
3. and the merger of relevant disciplines of science to enable multidisciplinary research and to confront said grand challenges.

The growing need for coordination between different public actors and policy fields also demands new governance mechanisms that can be more easily adapted to changes in the system, allow effective implementation, and recognize failures in the innovation system as governance failures, which depend on flexible solutions

This new holistic approach envisions innovation policy as overarching instrument in all societal and policy fields and depends on a level of inter-ministerial coordination that is not yet established in any country. Thus, it is a yet evolving approach, since the integration level of policy formulation, design and implementation are far from being as envisioned. In this new generation of policy formulation, the NSI approach continues to take a central role as analytical tool (Boekholt 2010, 353).

2.4.3. Innovation Policy and the NSI Approach

As outlined in the sub-chapter on definitions, innovation theory in the theoretical sense does not equal the utilization of innovation policy in actual policy making. The term, as utilized here, covers all major policies with an effect on innovation. Innovation policy as outlined by the NSI approach is best described as a policy system that comprises of a new rationale for government intervention, a range of new instruments, as well as new bodies for governance.

Since the NSI approach has primarily complemented existing approaches to policy making, rather than replacing them, there is indeed often a conflict of rationales and instruments (Chaminade and Edquist 2010, 110). The delimitation between the policies of the “classical theory” and “NSI approach” remains ambiguous. Many policy mechanisms in fact predate the theories that would later provide the theoretical rationale for their implementation, or their justification has shifted to a new theoretical foundation (Edler and Fagerberg 2017, 3).

While policy making shaped by the NSI approach also incorporates policy solutions employed by the classical theory, it differs in its rationale for government intervention. The central divergence between the classical theory and the NSI approach originates in the former’s assumption of market failures, and the latter’s focus on systemic failures. This in turn affects the expected result of government intervention. While under the classical approach a market equilibrium is achievable, the NSI negates its possibility. Since the NSI also rejects the notion of optimality, the policy maker is characterized as an “adaptive one”, rather than the classical “optimising one” (Chaminade and Edquist 2010, 102–106).

The NSI’s adaptive policy maker thus needs to continuously calibrate the policy portfolio. Policy formulation is shaped by theory, economic and scientific indicators, and subjective judgments. When it comes to the envisaged results, the implementation of policies includes a high level of uncertainty. Hence the ex-post, but also ex-ante evaluation of policy measures is crucial for successful policy making. The NSI approach acknowledges this importance of experimentation and learning from mistakes. To enable such evaluations, objectives and instruments of policy have to be clearly defined. In fact, innovation policies are always characterized by some sort of selectivity.

This selectivity results from an unavoidable focus on selected sectors, regions, or specific research or technological fields. On the national policy level, selectivity is present when chosen technology systems are promoted. Even the adoption of science or educational policies targeting human capital may likewise be driven by the ambition of developing national competencies in distinct technology fields. While neutral in the theoretical approach, the choice of policy targets is often driven by the lobbyism of interest groups (Chaminade and Edquist 2010, 105–110).

Effective policy making is regularly impeded by the fact that the positive or negative impact of an NSI’s structural elements is difficult to access. Strong networks for example may either support knowledge diffusion or lead to lock-ins. Thus, the rationale of policy mechanisms should first consider the dynamics of the system, rather than the nature and historical emergence

of its components. Here the functional analysis, outlined in section 2.3.3 plays an important role, as it allows a “dissection” of the system.

The relationships between the structural components of the system also matter, since the unique features of each NSI have to be considered. Policy formulation should always be driven by actual achievements, measured through indicators estimating the output of the system. Policy makers also have to consider that some problems in the system can be solved, often more efficiently, by actors in the system itself (Bergek et al. 2010, 130–134).

Forms of Government Intervention

According to Chaminade and Edquist (2010, 101), the classical approach identifies four central types of government intervention. These are the provision of public goods, the mitigation of externalities, the reduction of market entry barriers, and the elimination of inefficient structures in the market. Aside from these crucial forms of government intervention, other less important forms exist as well. The NSI approach on the other hand defines three major aims of government intervention. First, to fix obstacles within the innovation system or to support the emergence of new systems. Second, to encourage adaptations in the system’s support structure, specifically the emergence and further development of institutions, organizations, and networks. Third, to motivate transition and prevent technological lock-ins.

Edler and Fagerberg (2017, 5) provide a more defined typology of innovation policies, comprising of three main types: mission-oriented, invention-oriented, and system-oriented policies. Mission-oriented policies are oriented towards providing technological solutions for grand challenges and cover the whole innovation cycle. Recent undertakings in the context of climate change are an example for such policies, but as outlined above, they have a long history in the defence sector (Ergas 1987, 193–194). Invention-oriented policies on the other hand concentrate on particular R&D phases, while excluding subsequent innovation steps. These are utilized in the scope of science and technology policy with the aim of providing positive externalities to society. System-oriented policies on the other hand are a more recent addition to the policy portfolio and linked to the NSI approach. This type of policy is geared towards affecting the links between components of the innovation system.

More detailed innovation policy typologies have been developed by Boekholt (2010) and Edler and Fagerberg (2017). Boekholt in fact offers two different frameworks. The first one, displayed in Table 2, categorizes relevant “RTDI-policies” according to policy type. It shows the variety of innovation-oriented policies, stretching from those focusing on R&D, to theme specific ones, as well as the relevance of issues such as institutions (laws), finance and human resources. The

taxonomy presents a practicable separation in categories for subsequent use in the analytical framework.

Table 2 – RTDI-policy Taxonomy (Boekholt 2010, 354)

Main category	Types of instruments
Generic R&D policy (public sector)	• Discretionary institutional funding for R&D activities (e.g. block funding to universities and research centres) • Competitive R&D project grants • Support for R&D project infrastructures • Selective support for centres for excellence • Structural reform of public research sector
Generic R&D policy (private sector)	• Discretionary institutional funding for R&D (e.g. block funding for firms) • Competitive R&D project grants • Competitive R&D loans • R&D-friendly procurement
Thematic/sector policy	• Selective (collaborative) R&D support schemes • for existing high-technology sectors/technology domains • for new high-technology sectors • for low- to medium-tech sectors • for specific societal issue
Linkage policy	• Collaborative R&D programmes without thematic focus • Technology platforms and similar “stakeholder programming” actions • Cluster policies and regional growth pole policies • National support for science parks and other co-location schemes • Support for other university-industry linkage mechanisms (e.g. university liaison offices) • Support schemes for spin-offs
IPR policy	• Reform of IPR regulations • Support schemes to help secure IPR
Financial and fiscal policies	• Risk capital for R&D measures • Loan and equity guarantees for R&D investments • R&D tax relief measures for companies
Human resources policies	• Efforts to make S&T more attractive for pupils, students and graduates • Subsidies for hiring S&T personnel • Tax incentives for (foreign) ST&E personnel • Immigration policies for ST&E personnel

Fagerberg and Edler's (2017) narrower innovation policy typology differentiates policies according to supply side and demand side. For policies affecting both the supply and demand sides, the authors designate the respective relevance.

Table 3 – Typology of Supply and Demand Side Innovation Policies (adapted from Edler and Fagerberg 2017, 13)

Supply Side		
Fiscal incentives for R&D	Entrepreneurship policy	Policies to support collaboration
Direct support to firm R&D and innovation	Technical services and advice	Innovation network policies
Policies of training and skills	Cluster policy	
Demand Side		
Private demand for innovation		Public procurement policies
Mixed policies	Relevance for supply	Relevance for demand
Pre-commercial procurement	x	xxx
Innovation inducement prizes	xx	xx
Standards	xx	xx
Regulation	xx	xx
Technology Foresight	xx	xx

Boekholt's even more detailed STI-taxonomy likewise differentiates between supply side (knowledge creators) and demand side (knowledge users) targeted policies, but furthermore also distinguishes the differences between the public and private sectors. Policies that affect the links between the fields created by this fourfold differentiation are defined as "bridging initiatives". The detailedness of the taxonomy reflects the extended scope of modern innovation policies.

Table 4 – STI-policy Taxonomy (adapted from Boekholt 2010, 347)

	Public Sector	Bridging Initiatives	Private Sector
Knowledge Users	Support for science/technology educational institutions Support for government “knowledge workers”	Public sector bodies providing technical information services Public sector bodies providing metrology services Public sector bodies providing patent and licence information Public sector bodies providing consultancy advice for firms	Mostly policies belonging to other policy areas (business development, training, regulatory framework etc...) Subsidy for technology feasibility studies-technology audits Subsidies for hiring technicians in firms
Bridging Initiatives	ICT network infrastructure support Training by research	Systemic STI policies	Subsidised technology transfer and adoption schemes Technology brokerage schemes Support for the growth of private sector “intermediaries” Technology demonstration initiatives
Knowledge Creators	Support for research equipment infrastructure in universities Support for government labs Support for basic science Support for generic collaborative research between universities Support for networks of research excellence	Support for targeted collaborative research between universities and industry R&D services provided by government labs to industry R&D services provided by universities to industry Technology transfer infrastructure University/industry personnel exchange schemes for R&D staff Spin-off promotion policies University Liaison Offices Targeting R&D to areas with commercial potential Hiring subsidies for scientists	Subsidies for market-oriented R&D Product development assistance R&D tax incentives Innovation credits Favourable IPR regimes Inward investment schemes for R&D-intensive industries

The scope of innovation policies has considerably broadened and comprises of a high number of different mechanisms, as the introduced typologies and taxonomies on innovation policies display. These typologies cover the whole range of policies employed in industrialized economies, and thus are not always specifically relevant for the defence sector.

Defence is indeed a distinct sector of the economy and possesses a number of unique characteristics that differentiate it from other parts of the economy, specifically when it comes to market dynamics, the role of public organizations, linkages, and finance. Thus, the last sub-

chapter of the theoretical discussion below assesses these characteristics. This is crucial for the subsequent development of an appropriate analytical framework for the defence sector.

2.5. Innovation in the Defence Sector

2.5.1. The NSI Approach for Sector Specific Studies

The systems of innovation considerably vary from sector to sector. Malerba's (2005, 380–383) review of research literature and case studies has shown that differences can be found according to sectoral knowledge bases, actors, links and relationships between actors, and relevant institutions. This is due to the variations in R&D intensity, market structure, industrial dynamics and technological regimes.

Furthermore, technological regimes evolve over time, affecting their dynamics. Young sectors are characterized by low entry barriers, continually evolving knowledge bases and firm's higher innovativeness, but those characteristics transform over time as the sector evolves. This evolution also affects the relationship between net producers of knowledge and technology, and net users.

Table 5 – Sectoral Innovation Types (summarized from Malerba 2005, 384)

Sector type	Focus of Innovation	Sources of Innovation	Examples
supplier-dominated	new components and equipment	learning-by-doing; learning-by-use	textile, services
scale-intensive	process innovation	R&D and learning by doing (internal); equipment producers (external)	steel, automobiles
specialized-supplier	performance improvement, reliability, customization	tacit knowledge and experienced of skilled technicians (internal) user-producer interaction (external)	equipment-producers
science based	product and process innovations	internal R&D universities and public research laboratories general science advancements	pharmaceuticals, electronics

In this context, a sector can be defined as “a set of activities that are unified by some linked product groups for a given or emerging demand and which share some common knowledge” (Malerba 2005, 385). Writing in the framework of the NSI approach, for a sectoral case study Malerba (2005, 385) thus proposes a focus on knowledge and technical domains, actors and networks, and institutions.

In reference to Pavitt's (1984, 364) still relevant typology of firms, Malerba (2005, 384) defines four categories of innovation sector types: supplier-dominated, scale-intensive, specialized-supplier, and science-based sectors. These sector types are characterized by different forms of innovation patterns. Table 5 displays that this typology is delimited by product groups. The defence sector, on the other hand, is characterized by the specific demand of the armed forces. This demand is created by the nation state's sole authority for national defence and overseas military operations, which can be summarized as its "National Defence Organization" (NDO) (Markowski, Hall and Wylie 2010, 2). The NDO's central element are the armed forces, which rely on a vast support structure both inside and outside of the actual military structure. It encompasses not only uniformed, but also civilian personnel, policy making bodies, and the domestic defence industry. The acquisition of products and services for the sustainment of the NDO is facilitated by the generically named "Defence Procurement Agency" (DPA) (Markowski, Hall and Wylie 2010, 27-28). Considering the size and international leadership of the US defence sector, it is often used as an example for respective policy decisions and market dynamics.

2.5.2. Traditional Characteristics of the Defence Sector

Although defence projects were among the first undertakings in, and drivers of, the emerging STI-policy field, compared to civilian markets the defence sector is characterized by significantly different dynamics. The sector's crucial characteristic is a de facto monopsony, since the government, or more specifically the armed forces, are the sole customer for the products of this sector. Although defence products may be exported, the government may and often does regulate such exports through institutions (Matelly and Lima 2016, 66).

The limited demand created by this monopsony, rising costs for defence products, increasing technological complexity, and firm specialization, allow only a few defence-focused companies to survive in the market. Thus, defence markets are also often characterized by oligopolies and product-specific monopolies. Oligopolies and monopolies, and the limitations of contract arrangements, have been cited as the most important drivers for the sectoral prevalence of cost overruns and non-adherence to schedules (Sandler and Hartley 1995, 115–116).

Task and doctrinal changes in the wake of the Cold War have triggered a transition towards a new model for defence procurement and the sector as a whole. This transition is a continuous process, and many of the features and problems associated with the traditional market form continue to exist. The progress of the transition varies between countries, and the last decade has seen the re-emergence of peer-to-peer power competition, and thus traditional military tasks

are receiving increased attention once more (Molas-Gallart 2010, 260–261). It is therefore necessary to both outline the traditional characteristics of the defence sector, as well as those of the transitional one.

Organizations and Actors

The defence sector comprises of both public and private organizations and actors. The body at its centre and indeed defining the sector is the “Defence Procurement Agency” (DPA). It comprises of the organizational structure facilitating defence procurement for the armed forces. The DPA is to be understood as overarching catch-all term, as countries differ in the centralization of their procurement structure. The US for example has retained branch specific DPAs, while smaller countries have centralized it, or due to the limited size of their militaries always had only one central body.

Furthermore, research, development and actual procurement may be facilitated by one centralized body or by separate ones. Another differentiation is the organizational autonomy. While some DPAs are part of the military hierarchy, others are under the authority of the civilian administration (Markowski, Hall and Wylie 2010, 72–75).

The suppliers of defence products and services can be summarized to constitute the “Defence Industrial Base” (DIB) (Markowski, Hall and Wylie 2010, 86–86). The products and services procured by the DPA comprise not only of weapon systems themselves, but also of administrative material and more importantly components such as optical devices or computer chips. Such products often are of dual-use nature, such as that they can be both employed for military and civilian purposes. Likewise, suppliers themselves may exclusively produce for the demands of the NDO or be active in both the civilian and defence markets (Sandler and Hartley 1995, 182–85). The limited size of the defence market and the entry of non-traditional players into defence procurement mean that many defence suppliers actually achieve their main revenue in the civilian market.

Due to the vast scope of potential suppliers, the definition of the DIB is a complex undertaking. Broad approaches define the DIB as constituting of all firms supplying the Ministry of Defence (MoD) or the armed forces. Alternatively, the DIB may include all economic sectors with relevance for national defence (Taylor and Hayward 1989, 1). A slightly more limited definition includes all these sectors, but only if their supply is rapidly scalable for the rising demand in war time (Haglund 1989, 1–2). Considering that the number of defence suppliers has rapidly increased, such broad definitions are analytically problematic.

More limited definitions only include those industries and sectors that are dominantly oriented towards supplying the NDO (Todd 1988, 14–15). Such definitions have become outdated due to the opening-up of the defence market, and the market-entry of specialized firms supplying dual-use technology. Thus, current definitions by public agencies have adopted broad definitions, such as including all suppliers (U.S. Congressional Research Service 2018; Briani et al. 2013, 13).

Bergstrom et al. (2008, 11–12) distinguish four major company types within the modern DIB that constitute four levels of the supply chain. The uppermost layer consists of prime contractors, which are lead systems integrators and producers of weapons and platforms. The underlying supply chains comprise of three tiers. Tier 1 contractors are specialised system producers and supply complete sub-systems or major components. Tier 2 contractors are mostly SMEs that supply components as well as services. These companies dominantly produce dual-use technologies and services, and thus do not appear as classical defence companies. Tier 3 contractors are likewise SMEs that supply dual-use products and services. They supply commodities and general services, as well as general infrastructure such as communications, training, and transport. In the EU, tier 3 companies are not listed as defence companies.

System-integrators are prime contractors, which supply weapon platforms, have become the nucleus of the defence industrial sector and constitute the major defence companies. They take over the role of merging components from various supply chains into complex systems (Kolmykova 2016, 183). Their importance has continuously increased, due to growing technical complexity and the high entry-barriers created by military specifications and standards (Zervos and Swan 2009, 28).

Over time the emergence of a few prime contractors, through mergers and acquisitions, has strengthened the power of the private sector towards the government (Molas-Gallart 2010, 254–256). This development has had a negative impact on innovativeness, aggravating structural problems that were one of the drivers for the subsequent opening of the sector (Zervos and Swan 2009, 40).

Defence firms did not only merge into major bureaucratic conglomerates, but also increasingly specialized according to market dynamics or policy decisions. The relationship between them and the government can be characterized by “customer-led innovation” due to the role of the armed forces as “intelligent customer”. In the traditional defence sector, the government often retained major in-house R&D capabilities and restricted ownership of defence industries, while maintenance was internally handled by the armed forces. The provisioning of R&D by the

public hand reduced the need for private investment, furthering the development of today's industrial complexes (Molas-Gallart 2010, 254–256).

In-house production of defence products was seen as a necessity to avoid contractual limitations inhibiting a quick scale-up of production in time of war. Additionally, it allowed the control of sensitive technologies, although over time internal production became inefficient and problematic for the innovativeness of the sector (Markowski, Hall and Wylie 2010, 167–68).

The aforementioned Vannevar Bush Report of 1945 provided the impetus for establishing mission-oriented defence policy projects in the scope of technology policy. Though Bush argued for the establishment of a major civilian research organization that would conduct such defence related projects in the US, this organization was not created. Due to its sensitive nature, defence R&D remained in the closed sphere of major public laboratories, the defence industry, and restricted university research programmes. Defence research developed as a closed, top-down process. In the US only the nuclear weapons laboratories gained some level of independence, due to being controlled by the Department of Energy (Molas-Gallart 2010, 248–252).

Policy formulation alike remained a closed hierarchical process and controlled by a so called “iron triangle” of the armed forces, defence-related politicians and the respective industry. It was driven by military strategy and active lobbying, building-up on the work of major research institutes such as the RAND Corporation. The intimate relationship between the private and public sectors, and increasingly blurred borders between them, triggered a phase of critical academic research and the Western fear of the “military-industrial complex” in the 1980s (Molas-Gallart 2010, 250–255).

Market Dynamics

Defence economics as separate research field evolved in the early 1960s. It encompasses all economic issues related to the NDO, with a specific focus on defence spending, the defence market, as well as those elements of technological change and international relations that have an impact on defence (Sandler and Hartley 1995, 5–6). The early phase of research, from the 1960s up to the 1980s, showed that firm behaviour in the defence sector indeed deviated from the civilian market. Generalized, civilian firms strive to increase the cost-efficiency of their mass-manufactured products. Defence firms on the other hand display a tendency of developing increasingly more expensive products, often driven by military demand and doctrine. This reduces the number of products sold and increases complexity and the costs for operation and maintenance.

Since prices were based on cost plus fee schemes, the early phase of research showed that cost alone played less of a role for firms. The early adoption of systems with technical and market uncertainties led to cost-overruns and latter were further aggravated by bureaucratic red tape. Costs were in fact two to three times higher than in the civilian sector, which led to the identification of a “cost-maximising behaviour” (Molas-Gallart 2010, 255–256).

Kaldor (1981) described the emergence of “baroque” military systems that are characterized by such increasing complexity. According to her, military conservatism incorporates the tendency to retain main weapon systems, instead of replacing them, while adapting them to increase their capability. Thus, new generations of military products became increasingly complex, which in turn complicated operation and maintenance, as well as increased the costs of their procurement and maintenance.

Thus, the traditional defence market’s central dynamics are the formation of monopsonies and monopolies, rapidly rising costs and complexity, and the emergence of ever more expensive weapon platforms and decreasing acquisition numbers. Linked to policy decisions such as the deliberately barring of the market entry of new players, over time this led to decreased competitiveness and innovativeness, and increased the relevance of civilian high-technology sectors.

Policy Portfolio

The activities undertaken by the DPA are steered by the national Defence Industrial Policy (DIP), which is a product of overarching national defence strategies and doctrine. The DIP focuses on the aim of providing the necessary defence products to the armed forces, in order to implement overarching defence policy demands. In theory it also aims to do this in the most cost- and time-effective way, while achieving the highest quality products (Markowski, Hall and Wylie 2010, 3).

Nonetheless, as outlined above, the investments in defence R&D were also conceptualized to provide positive externalities to the national economy. The overall DIP has been employed to boost economic development and growth, increase employment, improve the balance of payments through defence exports, or to support the innovativeness of the civilian economy (Markowski, Hall and Wylie 2010, 172–175; Fevolden and Tvetbråten 2016, 178).

Fevolden and Tvetbråten (2016, 178–179) identify three general types of defence industrial policies with relevance for procurement. The first includes discriminatory practices that exclude foreign competition, offsets, and cost-share/work-share contracts. Offset contracts force

suppliers to utilize supply chains within the procuring country, either directly by integrating domestic defence firms in the production line, or indirectly by buying other goods and services from the domestic economy. Cost-share/work-share contracts are utilized in international collaboration for development and joint procurement, with cost distribution in general being equivalent to the final procurement volume of each country.

The second type of DIPs are R&D-related, when the DPA takes over part of the contractors' project costs for the development or improvement of defence products. The third type of defence industrial policies are arms export policies, which are employed to prevent the proliferation of military technology to threatening nations or actors involved in active warfare.

Governments may decide to apply discriminatory practices in order to exclude foreign competitors and ensure supply dependability and domestic industrial capability (Markowski, Hall and Wylie 2010, 170–172). For procurement both from international and domestic suppliers, the DPA may decide to buy from a chosen company, a specific group, or open the contract to all potential competitors. Thus, source selection requirements can be divided in competitive, parallel, and sole sourcing (Markowski, Hall and Wylie 2010, 168–169).

When it comes to defence contracts themselves, DPAs have employed a number of policy schemes that were adapted over time, in order to mitigate risks for both suppliers and the public hand. The two most important categories are direct contracts with one or multiple suppliers, and competitive tenders for finding the best suppliers. Despite that, competitive tenders are often discriminatory as well, when limited to invited firms (Sandler and Hartley 1995, 117).

Despite the development of more specified contract types, ambiguity and asymmetric information remain a characteristic of defence procurement. Even when liabilities are specified, the government is often forced to cover cost-overruns. This is due to the timely demand for systems or components, already conducted investments, and the potential damage to strategic industries (Markowski, Hall and Wylie 2010, 127–129). Many DPAs have therefore emphasized the implementation of institutions addressing transparency of costs and profits, and the introduction of competition throughout the industrial project life-cycle (Sandler and Hartley 1995, 133). Various pricing arrangements tackling this issue are summarized in the non-exclusive table below.

Table 6 – Contract Types (summarized from Sandler and Hartley 1995, 136–137; Markowski, Hall and Wylie 2010, 126–128)

Contract Type	Characteristics
Fixed-price	The DPA pays a fixed amount to the manufacturer/developer.
Cost-reimbursement	The DPA takes over all costs of the manufacturer/developer.
Cost-sharing	The DPA takes over a determined share of the costs.
Cost-plus	The DPA takes the role as insurance for projects with high risks. This can reduce efficiency, as quality and schedule requirements are less pressing for suppliers.
Incentive	A mix of fixed-price and cost-plus contracts, where targeted costs, profits, share ratios, and the public hand's maximum liability are determined.

2.5.3. The Transitional Defence Sector

Although the top-down reform attempts first initiated in the US in the 1990s mostly failed to materialize, subsequently a broader change of technological regimes and military doctrine transformed the traditional closed defence sector. Molas-Gallart (2010, 258–263) identifies drivers of transition both in respect of doctrinal and technological factors.

First, the late phase of the Cold War saw the emergence of the so-called “Revolution in Military Affairs” (RMA). The RMA is the theoretical stance that in certain historical periods emerging technologies allow a complete overhaul of the way warfare is conducted. From it derived was the subsequent doctrinal shift towards network-based, rather than platform-based, operations. This created a demand for cutting-edge technology, which could only be supplied by non-traditional defence suppliers.

Second, the change was initiated through a rapidly shifting threat landscape. The doctrinal focus on Cold War era large-scale wars against peer-competitors shifted to the notion of “new wars”. These wars are characterized by operations abroad in civil conflicts and failed states, in the scope of which armies take over the role of security forces. The current resurfacing of near-peer and peer-competitors in military strategy has not reversed this process, but rather extended the challenges facing the armed forces. Third, the emergence of a new form of high-profile terrorism against domestic civilian targets further facilitated the merger of the defence and security fields. Although primarily assessed from a Western perspective, these drivers have also affected East Asian countries, as outlined below.

As a consequence of this twofold merger of defence and security, new policies and R&D goals combine both traditional military goals and new approaches to national security. While on the

organizational level defence and security often remain separated, the distinction between the respective policy fields has become increasingly blurred. This has paved the way for new governmental organizations and private actors to enter the field of (defence) R&D and policy making. The number of technologies with relevance for defence in the market has rapidly grown, as is outlined in more detail below (Molas-Gallart 2010, 260–263).

Shifts in the Organization and Actor Landscape

On the organizational level, the shifts in procurement policy have been accompanied by a trend towards increased centralization of the DPA. This encompasses not only the horizontal integration of branch specific DPAs (the US being an exception), but also of the vertical integration concentrating the management of the whole R&D to procurement cycle in one body. The reform process has also affected the autonomy of the DPA. Canada for example has organized its unified DPA under authority of the Department of Public Works and Government Services Canada (PWGSC), while in Australia the Premier and Cabinet retains the authority over ultimate decisions on defence acquisitions (Markowski, Hall and Wylie 2010, 72–74). Similar reforms have been undertaken by both Japan and South Korea.

France established the Direction Générale de l'Armement as unified defence procurement and technology agency in 2003. Going beyond the role of a traditional procurement agency, the DGA was envisioned to accumulate technical expertise in defence affairs, while building a network with established defence suppliers and civilian research bodies (Lazaric, Mérindol and Rochhia 2011). In the UK, the centralized “Defence Evaluation and Research Agency (DERA)” had already been established in the frame of privatization reforms in 1991. The British Ministry of Defence only retained a core competence in form of the Defence Science and Technology Laboratory (Molas-Gallart 2001, 426–30).

The US already created its Defense Advanced Research Projects Agency (DARPA) in 1958. Nonetheless, post-9/11 DARPA also underwent changes, and the US Department of Defence subsequently established more specialized bodies such as the Defense Innovation Unit (DIU) in Silicon Valley. The DIU has the specific task of migrating civilian innovation into the defence sector (Fiott 2017, 426). Another example is Israel, where the DIB is characterized by a vast number of small high-technology firms that produce dual-use technology for both the armed forces and the civilian market. The military maintains a close relationship with these firms, which are often founded by former member of the forces (Broude, Deger and Sen 2013, 48–49).

New public organizational players have also emerged in the defence field. In the US the Department of Homeland Security has created a considerable defence and security R&D budget (Molas-Gallart 2010, 264). The European Union presents one of the most striking examples of a new player in the defence sector. Although defence procurement itself remains under the sole authority of the member states, the Commission and the European Defence Agency have created new R&D defence programmes (European Commission 2019b).

The breaking down of boundaries between the defence and civilian sectors has also affected defence research itself. The decrease of R&D budgets, as well as the loss of the armed forces' lead-user role has facilitated a reorientation of defence R&D laboratories. While the management approach of such laboratories varies between countries, there is a general trend towards opening them for the civilian market. In some countries, such as the UK, laboratories and research institutions have been commercialized or even privatized. Commercialization has allowed these actors to utilize their research in the commercial market through licencing, joint-ventures or spin-offs. Vice versa, it enabled the adoption of technologies developed outside of the traditional defence actor landscape (Molas-Gallart 2010, 268).

Privatization is not a clear-cut international trend though. For example, new problems arising from it have led Australia to re-nationalize cost-intensive infrastructure such as shipyards, and the armed forces now share it with private contractors (Markowski, Hall and Wylie 2010, 167–68).

Shifts in Market Dynamics

The second reason for the transition of the defence sector is rooted in technological change and associated new market dynamics. Due to the lagging innovativeness of the defence industry and the growing capacity of civilian high-technology industries, the armed forces have lost its role as “first user”. They have become more dependent on dual-use technology and non-traditional suppliers from the civilian sector.

Civilian markets have increasingly offered a greater growth potential, allowing higher investments in R&D, and were hence over time outperforming traditional defence suppliers. The defence sector was furthermore both pressured by the reduction of budgets in the post-Cold War period and by rapidly increasing costs due to Kaldor's complex “baroque” systems. The “Revolution in Military Affairs” and the subsequent doctrinal shift towards network-based, rather than platform-based, operations further increased the demand for new technologies developed in the civilian sector (Molas-Gallart 2010, 263).

While defence R&D has always encompassed dual-use technologies, the drivers outlined above emphasize the relevance of technology sourcing from the civilian sector. Technologies sourced from non-traditional civilian suppliers fall into two categories. So called “commercial-off-the-shelf” (COTS) products and technologies are freely available in the market and can be adapted to military demands. “Non-developmental items” (NDIs) are products specifically developed for defence purposes but are developed by private actors. The rising relevance of COTS products and NDIs for defence is a result of to the increased capacity of the civilian sector to provide a flexible supply of cheaper and higher quality products.

Hence for many governments a reform of R&D and procurement policies became necessary. The previous inflexible portfolio of specifications, standards and contractual procedures has to be adapted to incentivize the entry of non-traditional suppliers. New procurement forms shift some risks associated with R&D to suppliers and reduce costs for the government. Still, the threat of unexpected long-term costs persists, since the armed forces are now becoming dependent on civilian suppliers and often do not possess the IPR rights of procured components.

For complex systems specifically, the risks created by components’ short life-cycles and long-term maintenance needs have created a new dependency. Due to the early obsolescence in the civilian market and thus the decrease of producers, an exploitable dependence on a few specialized suppliers can arise (Molas-Gallart 2010, 267–268). This underlines the necessity for civilian-defence linkages and technology transfers.

Shifts in the Policy Portfolio

As displayed in Table 7, DPAs have strived to develop advanced financing arrangements to mitigate the threat of cost overruns in defence procurement. The demand for higher innovativeness and technology-sourcing from non-traditional actors has likewise affected the policy portfolio. Tenders and prizes were established elements of the R&D landscape already but have gained prominence as tools to boost competitiveness and innovativeness, and are more widely applied (Matelly and Lima 2016, 65).

Tenders are calls for proposals that outline factors such as price, schedule, or potential capabilities, and allow the choice of one firm or conglomerates. Prizes are utilized for competitions, where companies strive to present the best product fulfilling outlined specifications. The winning company subsequently receives the contract for manufacturing or adapting a defence product.

Tenders and prizes were developed in the context of rapidly evolving technology and a rising demand for innovation, which has made long-term R&D contracts increasing unfeasible. Under prize designs, profits are often specifically restricted to the production phase, in order to drive suppliers to invest in successful innovation, as they will only achieve profits when acquiring the final procurement contract. On the other hand, this may also induce companies to overstate capabilities and thus requires a strict evaluation system. Considering that unsuccessful contenders have to face sunk costs, it may also discourage small- and medium-sized enterprises (SME) from innovative high-technology niches (Rogerson 1989, 1285–1287).

The last decade has seen the emergence of more coherent policy portfolios for R&D and procurement. While the United States is the long-standing pioneer in the field, smaller countries such as the UK, Australia and Canada have set-up their own defence innovation systems since 2015. As outlined before, one of the most recent examples for such a distinct programme aimed at boosting innovation in the defence sector is implemented in the European Union.

Table 7 – New Policy Mechanisms for Defence Innovation

Country	Programme / Organization	Year
United Kingdom	Defence Innovation Initiative	2016
	Defence Security Accelerator	
	Defence Innovation Fund / Fund for Disruptive Capabilities	
Australia	Defence Innovation System	2016
	Defence Innovation Hub	
	Next Generation Technologies Fund	
Canada	Innovation for Defence Excellence and Security (IDEaS)	2018
France	Defence Innovation Lab (Defence Innovation Agency)	2018
EU	Preparatory Action for Defence Research	2017
	European Defence Agency Defence Innovation Prize	2018
	European Defence Fund (2021)	2021

The new policy mechanisms displayed in Table 7 address the same goals: boosting competition, incentivizing the private sector, funding “disruptive technologies”, fostering networks with universities, civilian industries, and SMEs, and establishing innovation hubs. New organizations created in this scope also include specific bodies for technology foresight, a central element of modern innovation system management (DST Group 2018; IDEaS Team 2018; UK Ministry of Defence 2016).

The European Union's European Defence Fund follows the same rationale, while also amplifying the integration of the European DIB (European Commission 2019a). Since 2017, the European Defence Agency (EDA) implements the Preparatory Action on Defence Research (PADR) on behalf of the European Commission. In early 2019, the complementing European Defence Industrial Programme (EDIDP) was launched. While PADR covers defence research, the EDIDP encompasses subsequent steps of product development. Both programmes merged into the European Defence Fund (EDF) in 2021. Utilizing tenders and prizes, the European defence programme places attention on so-called disruptive technologies, which are technologies that may fundamentally change military capabilities.

The programmes do not only include discriminatory practices, competitive tenders and prizes, but also introduce competition throughout the product life-cycle, as calls outline very narrow technological readiness levels (TRLs) (European Commission 2018). TRLs are a framework to distinguish stages of product development. There are nine TRLs, reaching from basic research to testing, qualifications and operations (EARTO 2014, 3). The European programmes are exemplary for the transitional defence sector. Not only are they implemented by new actors and organisations, but they also aim at integrating and transforming existing civilian and defence value-chains and industries.

3. Analytical Framework

3.1. General Definitions

The literature review has shown that the national system of innovations approach provides the most utilizable concept for a comparative assessment of innovation systems. On the one hand this is due to its very design as framework, on the other hand due to its suitability for sectoral studies. The classical theory lacks specified explanations for changes in the system, for example in the transitional defence sector that is characterized by the expanding relationship with civilian industries. Furthermore, the NSI approach is better suited to cover the increased scope of the latest innovation policy generations as identified by Boekholt and other researchers.

The NSI approaches variations also integrate policies in form of the strategic innovation management and are thus fitting the top-down focus of this paper. Established literature on the NSI concept shows that the approach allows considerable flexibility to adapt the framework for specific sectoral studies. This chapter provides a NSI framework designed to catch the peculiarities of the defence sector.

In light of Malerba's (2005) research on the application of the NSI approach for specific sectors, the defence sector can be characterized by the monopsonist demand of the armed forces for products needed to sustain the National Defence Organization (NDO). The actors in this sector constitute the Defence Industrial Base (DIB). As the discussion on the DIB demonstrates, this constitutes a vast array of firms and research institutes from all sectors of the economy. It is thus practical to limit the definition of the DIB in the scope of this thesis.

In the scope of this thesis, the classical DIB is thus defined as all public entities, and public and private research institutes that are involved in the defence sector, as well as the private firms that constitute prime contractors, tier 1, and tier 2 firms as defined by Bergstrom et al. (2008). Firms are only recognized as belonging to the DIB as far as they supply final products (e.g. weapons or weapon platforms), components, technologies, research, or services (e.g. maintenance, technical training), specifically designed or utilizable for defence tasks.

Thus, the definition excludes general services such as the provision of food and administrative material, for example office supplies. Derived from it, the public and private entities that constitute the actors and organisations in the DIB also form the defence innovation system (DIS).

3.2. The Defence Innovation System

According to Bergek et al. (2010) and Edquist and Johnson (1997), the NSI comprises of three elements: organizations or actors, institutions, and networks. Fagerberg (2014) and Smits and Kuhlman (2004) have added the strategic innovation system management. Considering the characteristics of the defence sector outlined above, the focus of this thesis on the top-down management of defence innovation and the differences in the economic system of the analysed cases, a differentiation between public and private entities is required.

In the scope of this analytical framework, the defence innovation system (DIS) comprises of five elements: organizations, actors, networks, institutions, and the policy portfolio. The latter two elements together constitute the strategic innovation system management (SIM).

In reference to the original definition provided by Edquist and Johnson (1997, 46–47), organizations are defined as public “formal structures that are consciously created and have” the “explicit purpose” of implementing the policy portfolio in the defence sector and conduct the tasks of the NDO, such as defence procurement. In the scope of organizations, the most important one is the DPA with its task of handling defence procurement and managing respective R&D.

While this organizational structure may or may not be centralized, the DIS can also include “mission-oriented” organizations in addition to the DPA, such as those facilitating linkages or promoting technology transfers. Thus, the element of organizations is assessed with a focus on the DPA’s horizontal and vertical integration, dedicated (mission-oriented) organizations and the separation of DPA tasks, as well as the relationship of the main DPA organization with the armed forces themselves.

Actors on the other hand are defined as public and private “formal structures that are consciously created”, are part of the DIS, and supply products, research, or services for the NDO. Thus, actors present the “knowledge creators” from Boekholt’s (2010) STI-taxonomy in Table 4. The element of actors encompasses the factors of market structure, private and public ownership, the nature of main research actors, and the entry of non-traditional actors. For the latter, an assessment of all actors is not feasible due to the number of relevant actors from high-technology and other industries. The same applies to SMEs, although their role in the DIS is assessed when possible. Both the assessment of market structure and ownership are highly relevant, considering the transformation from the traditional to the transitional defence sector.

The element of networks presents a challenge for the analysis, since implicit networks can only be assessed by a sophisticated analysis. This element is thus limited to the analysis of formalized networks, such as agglomeration and clusters, formal civilian-military partnerships, and their respective existence and development.

Considering the breath of Scott's (2014) typology for institutions, the definition applied in the scope of this paper is limited to laws and regulations that are utilized to affect the activities and the interactions between organizations and actors in the DIS. Thus, normative and cultural-cognitive institutions are excluded. This limitation is necessary due to the problem of measuring and assessing these two institution types without empiric research.

Institutions are assessed as a separate factor from policies, due to their overarching nature and respective permanence. This element encompasses regulations affecting ownership and investment, market entry, intellectual property rights (IPR), and arms and technology export control.

Both ownership and investment, and market entry regulations determine the admission of actors to the DIS. Ownership and investment regulations are assessed in the scope of permittance and regulation of private and foreign investments. Market entry regulations are assessed in the scope of the permittance and regulation of new actors entering the defence market. IPR regulation may both hinder and promote investments in defence, and as outlined in the discussion of government interventions under the classical innovation theory, have an impact on technology transfers. These are assessed in the scope of the management of publicly funded research results, dedicated defence IPR laws, and respective classification provisions.

Arms and technology export control are primarily assessed in the scope of technology retention and proliferation goals, while international collaboration is assessed under "linkage policy", and export promotion strategies under "financial policy". Regulations employed in the acquisition process are assessed in the framework of the policy portfolio. Thus the indicator of arms and technology export control focuses on schemes for export control and technology retention, as well as adherence to respective international treaties.

The policy portfolio encompasses all policies relevant for the DIS. Following the definition of Chaminade and Edquist (2010, 95) policies within the DIS are defined as "the public actions that influence innovation, processes, i.e., the development and diffusion of (product and process) innovations" in the defence innovation system. These include both those policies specifically implemented for the defence sector, and the general economic policies that affect innovation

and processes within the DIS. Excluded are policies that only have an indirect impact on the sector, such as educational policies that affect the populace and workforce as a whole.

Following Bergek et al. (2010), the analysis of the DIS, as defined above, not only focuses on the contemporary relationships between the five elements of the system, but also on the creation or adaption of organizations, entry or exit of actors, adoption or retention of institutions, the formation and management of networks, and changes in the policy portfolio. Thus, not only the contemporary state of affairs in 2021 should be assessed, but also their dynamic development to this point in a specified timeframe. It is especially important to present changes in the system in the context of their occurrence, be it by market forces, changes in policy direction, or as policy answers to systemic failures.

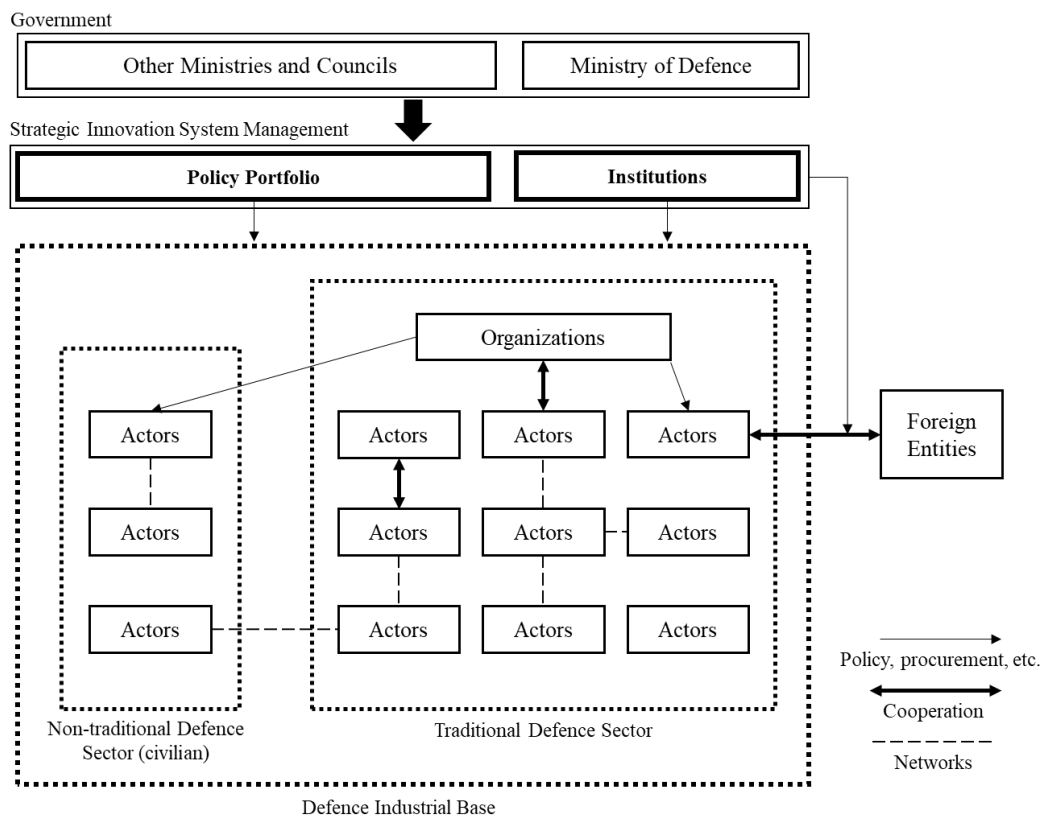


Figure 3 – The Defence Innovation System

3.3. Policies in the Defence Innovation System

The literature review outlines overarching typologies of dividing policies in science, technology, and innovation policies, or in mission-, invention-, and system-oriented policies. These general typologies are problematic. The first typology suffers both from ambiguity and definitional overlaps, as policy forms may fall into more than one category. Due to the latter argument, the second typology is also hardly applicable. On the other hand, the more detailed taxonomies of Boekholt (2010) and Edler and Fagerberg (2017) are designed for the overarching national

innovation system. Therefore, many of the included policy types bear little relevance for the peculiarities of the DIS.

Boekholt's RTDI-policy taxonomy (Table 2) provides the most applicable main categories for compiling a typology adapted to the DIS, while Edler and Fagerberg (Table 3) provide pertinent generalized policy types. Thus, the non-exhaustive list of relevant policy types in Table 8 can be derived from the established typologies and the literature review on the defence sector's characteristics. Specific classifications of defence industrial policy, such as those by Fevolden and Tvetbråten (2016) and Markowski, Hall and Wylie (2010) are "allotted" to the corresponding policy categories. As the aim of this thesis is the analysis of defence innovation systems, rather than the state of specific weapon technology programmes, thematic policies were excluded. Defence innovation accelerators are covered under issue of organizations.

Considering the monopsonist nature of the DIS and the strong role of public entities in the sector, the categories of "overarching policies" and "planning instruments" have been added. Overarching tenets cover defence reforms and their impact on defence industrial and procurement policies. Planning instruments cover the implementation of the strategic innovation system management for the defence sector, where requirements of the armed forces have a crucial impact. Additional instruments not listed in Table 8 are addressed in the case studies, if they are relevant to the respective DIS.

Table 8 – Main Policy Categories in the Defence Innovation System

Policy Category	Description and Types of Instruments	Consolidated Indicators for the Analytical Framework
Overarching Tenets	Overarching policy goals and reforms targeting or affecting the DIS	Overarching defence reform goals
Planning Instruments	Policy planning frameworks, including strategies and policy plans, targeting or affecting the DIS	Planning cycles, timeframes, continuity
Linkage Policy	Innovation network and linkage policies Support for centres for excellence Cooperation with civilian (non-traditional defence) firms Cooperation with universities and civilian laboratories Collaborative R&D programmes Cluster schemes International cooperation schemes and discriminatory practices Technology transfer and adoption schemes	Domestic and foreign linkages Policy foci

Policy Category	Description and Types of Instruments	Consolidated Indicators for the Analytical Framework
Financial Policy	Financial support schemes and tools Funding programmes and dedicated defence innovation funds Support schemes for civilian spin-offs	Preferential treatments, direct funding mechanisms Policy foci
Acquisition Policy	Competitive acquisition, and R&D grants and loans Sourcing, pricing and contracting policies; Discriminatory Practices Innovation inducement prizes and tenders	Competition, evaluation, transparency reforms Policy foci
Human Resource Policy	Recruitment policies for researchers and technical personnel Immigration policies for researchers and technical personnel	HR issues and policy response Talent recruitment domestic and abroad

While some instruments can be attributed to the evolution stages of innovation theory, applied innovation policy utilizes a mix of various instruments. As outlined in chapter 2.4.3., governments employing policy approaches still rely on instruments originating from the classical innovation theory and intermediary stages between it and the NSI approach. Associating the indicators presented in Table 8 with innovation theory stages is thus intricate. The results primarily display the tendency of the compared countries to reform their policy approaches. The analytical framework is thus a tool to:

1. provide a structure for the direct comparison of the case studies to identify similarities and differences;
2. specify the role of the government in the defence sector;
3. identify the utilization of classical and NSI reasoning;
4. determine the transformation of the defence sector, specifically in context of the transitionary defence sector.

Both the cleavage between the classical innovation theory and the network-centric NSI approach and the concept of the classic and transitionary defence sectors demand trade-offs in policy making. Both classical approaches place a strong government at the centre of the defence innovation sector and enable strict classification and technology retention. The NSI and transitionary defence sector concepts on the other hand focus on economic integration, placing linkages at the centre and defining the government as enabler, and thus demand liberalization. They hence require compromises in respect of control and classification. The significance and interpretation of the introduced elements and indicators are presented in Table 9.

Table 9 – Interpretation of the Analytical Framework

Element / Indicator	Interpretation
DPA Organizations	<i>Focus: Organizational structure and role</i>
Horizontal and vertical integration	Is the DPA organization fragmented or centralized? ➔ Fragmented: Classical defence sector, placing service branch demand above network enablement and synergy ➔ Centralized: Analogous to Western approaches in defence innovation ➔ Centralized: conceptualization as network enabler and central node
Dedicated organizations and separation of tasks	What additional organizations exist and what are their tasks? ➔ Additional organizations may have specific enabling tasks, for promoting technology diffusion and civilian-defence sector integration
Relationship to the armed forces	Is the DPA located within the armed forces or separately? ➔ Separate organization is an indicator for civilianization with respect to enablement tasks necessitated by the transitional defence sector
Civilian Organizations	<i>Focus: Role of organizations</i>
Authority and mandate for the DIS	To what extent are civilian organizations involved in the defence sector? ➔ Integrated industrial policy making and R&D funding is indicative for advanced, overarching innovation concepts focusing on networks, as well as for the integration of the transitional defence sector
Actors	<i>Focus: Ownership and sectoral separation</i>
Market structure	Is the market characterized by monopolies/duopolies and why? ➔ Indicative for the role of the government (policy) or free market forces (“baroque” defence products necessitating consolidation) ➔ Reliance on civilian and defence revenue is indicative for the separation of civilian and defence sectors
Private and public ownership	What share of the (classical) defence sector is in public ownership? ➔ Indicative for the role of the government as supplier of the NDO or as enabler of the market
Main research actors	Who are the crucial knowledge producers within the DIS? ➔ Indicative for the role of the government as supplier or enabler, and classic government intervention approaches ➔ Indicative for the transitional defence sector (civilian knowledge producers)
Entry of non-traditional actors	Were reforms implemented to open the market to civilian (and private) actors, and for which technological fields? ➔ Indicative for the transitional defence sector
Networks	<i>Focus: Networks and their reasoning</i>
Agglomerations	Are there defence industrial agglomerations and why? ➔ Indicative for geographical integration or separation from civilian industries (transitional vs classical defence sector)

ANALYTICAL FRAMEWORK

Clusters	Are there defence industrial or dual-use clusters and why? ➔ Indicative for civilian-defence integration (transitory) ➔ Utilization of late classical innovation theory, NSI approaches
Civilian-Military Partnerships	Are there formalized partnerships between the armed forces and civilian research actors? ➔ Indicative for the transitory defence sector and advanced linkage policy
Institutions	<i>Focus: Liberalization vs classification</i>
Ownership and Investment Regulations	➔ Liberalization allows conclusions on compromises necessitated by civilian-defence integration
Defence Market Entry Regulations	➔ Liberalization allows conclusions on compromises necessitated by civilian-defence integration and the demand for new-technology-based firms (NTBFs)
Intellectual Property Rights (IPR) Regulations	➔ Liberalization allows conclusions on compromises necessary to boost technology diffusion and incentivize research actors
Arms and Technology Export Control	➔ The regulatory framework allows conclusions on technology retention and international cooperation efforts
Policy Portfolio	<i>Focus: Policy tools and reform priorities</i>
Overarching tenets	➔ Overarching reform foci inform on the prioritization of specific elements and their drivers
Planning instruments	➔ The existence of a comprehensive planning portfolio is indicative for advanced innovation policy concepts ➔ Separation of the industrial life cycle by specific plans informs on advanced innovation policy concepts (e.g. dedicated innovation plans)
Linkage Policy <i>Domestic Linkages</i> <i>Foreign Linkages</i>	➔ The focus of domestic linkage policy informs on: - Theory: intra-sector (classical), inter-sector (late-classical, NSI) - The presence of transitory tendencies ➔ The focus of foreign linkage policy informs on: - Technology import and retention efforts - DIB capability and capacity
Financial Policy <i>Preferential treatments</i> <i>Direct funding mechanisms</i>	➔ The utilization of specific instruments in the context of budgetary trends informs on: - Preferential treatments to counter perceived market failures - Dedicated funding to prioritize innovation and integration efforts - Policy reasoning and innovation policy concepts
Acquisition Policy <i>Competition, evaluation, transparency reforms</i>	➔ The utilization of specific instruments informs on: - The priority for innovation enabling mechanisms - Priorities necessitated by the transitory defence sector, such as localization efforts and the demand for NTBFs
Human Resource Policy <i>HR issues and policy response</i> <i>Talent recruitment domestic and abroad</i>	➔ HR issues and response informs on the role of the government for this aspect ➔ Recruitment efforts inform on the role of the government, as well as on technology diffusion and absorption efforts

3.4. Timeframe

The conceptualization of the defence innovation system and the relevant policy mechanisms in Table 8 constitute the analytical framework for the subsequent comparative analysis. As outlined, latter versions of the NSI approach emphasize the assessment of dynamic changes in the system. Thus, it is not only essential to assess the contemporary relationship of the five presented elements, but also their adaption over time.

There are two possible approaches for the timeframe, during which the three cases can be compared. One is to utilize major defence reforms in each of the three countries as a starting point. This would result in different “starting points” for each case study. The other one is starting with a major shift in the geopolitical landscape. Considering that adaptations in the SIM are not always dependent on major reforms and to improve the comparability, this latter approach is the more pertinent one.

The most relevant contemporary shifts in the geopolitical and security landscape in East Asia, as well as globally, occurred at the beginning of the 1990s. First of all, the dissolution of the Soviet Union changed the elementary threat perception in China. This change was driven by the First Gulf War between the United States and Iraq, which displayed to Chinese observers the technological leadership the former had established. Consecutively, the Chinese domestic discussion on national defence shifted towards the relevance of a Revolution in Military Affairs (RMA) and the importance of information warfare. This “informatization” of warfare would emerge as a key element in later defence priorities (Shambaugh 2002, 69–76).

The discussion of an imminent RMA, the changing relationship between the US and its East Asian allies, and the rise of China as an expeditionary military power, also transformed the defence priorities of South Korea and Japan. This was further aggravated by the North Korean armament progress in strategic weaponry. South Korea launched a new reform drive towards a more sophisticated and ingenious defence industry in the late 1990s. It built on the preceding Yulgok indigenization project and subsequently led to the emergence of the country as a major arms supplier (Moon and Paek 2010).

In Japan, strains on the alliance with the US due to the countries reluctance to participate in the Gulf War, the Taiwan crisis of 1995/96, and increasing reluctance in the US for defence technology transfers, supported the military “normalization” of the country. The 1996 revision of the Japanese National Defence Programme Outline signified the transition from a “required” towards a “standard” defence force. It necessitated the acquisition of new capabilities and a qualitative build-up, in part to be fulfilled by domestic industries (Hughes 2004, 33–68).

The individual trends in the three nations were also shaped by the overarching merger of defence and security, as outlined in sub-chapter 2.5.3. Since this general dynamic is a characteristic of the post-Cold War period, it further underlines the suitability of the timeframe 1991 to 2021 – a compact 30-year timeframe – for the analysis.

3.5. Summarized Overview

The framework elements outlined in detail above, and the selected timeframe, are condensed in the compact analytical framework on the next page. The elements of the framework – i.e. the entities, relationships, and categories of the strategic innovation management system – are linked to each other. In order to allow a systemic discussion of each case study, the framework is structured to that end and the policy portfolio “slotted in”.

Table 10 – Summarized Overview of the Analytical Framework

Element	Focus of Analysis	Indicator	Timeframe
Policy portfolio	Overarching tenets	General defence reform goals	Changes 1991 – 2021 State of Affairs in 2021
	Planning instruments	Planning cycles, timeframes, continuity	
Organizations	DPA organizations	Horizontal and vertical integration Dedicated organizations and separation of tasks Relationship to the armed forces	
	Relevant civilian organizations	Authority and mandate for the DIS	
Actors	Actor landscape of the traditional defence sector	Market structure, private and public ownership Main research actors, entry of non-traditional actors	
Institutions	Ownership and Investment Regulations	Permittance and regulation of private and foreign investments	
	Defence Market Entry Regulations	Permittance of new actors to the defence market	
	Intellectual Property Rights (IPR) Regulations	Management of publicly funded research results Dedicated laws Classification provisions	
	Arms and Technology Export Control	Schemes for export control and technology retention International treaties	
Policy portfolio	Linkage Policy	Domestic and foreign linkages Policy foci	
Networks	Agglomerations Clusters Civilian-Military Partnerships	Existence and development of respective networks	
Policy portfolio	Financial Policy	Preferential treatments, direct funding mechanisms Policy foci	
	Acquisition Policy	Competition, evaluation, transparency reforms Policy foci	
	Human Resource Policy	HR issues and policy response Talent recruitment domestic and abroad	

5. Case Studies

5.1. People's Republic of China

5.1.1. Policy Portfolio: Overarching Tenets and Planning Instruments

The Chinese defence sector has historically been characterized by a top-down steering approach, adopted from the Soviet model, and by techno-nationalism. Defence industrial policy has been focused on self-sufficiency and indigenous innovation (Cheung 2009a, 6). With the advent of the 21st century and accompanying reform undertakings, the approach has also been referred to as “neo-techno-nationalism”, due to the pursuance of techno-nationalist goals through the utilization of globalization, or as “innovation with Chinese characteristics” (Cheung 2009a, 137; Cheung 2011a, 326).

During the last three decades, Chinese defence acquisition policy has been driven by both its growing economic prowess and increasing demands on the capability of the People's Liberation Army (PLA). The latter element is clearly visible in the increasing reach of the Military Strategic Guidelines (MSG), which guide defence industrial policy. The goal of transforming the PLA from a Cold-War era continental land army into a high-technology expeditionary army necessitated reforms in both structure and doctrine.

Table 11 – Military Strategic Guidelines of the PLA 1980 – 2021 (Fravel 2019, 35)

Year	CMC Chairman	Name / Doctrine
1980	Deng Xiaoping	Active defence
1988		Dealing with local wars and military conflicts
1993	Jiang Zemin	Winning local wars under high-technology conditions
2004	Hu Jintao	Winning local wars under informatized conditions
2014	Xi Jinping	Winning informatized local wars

The so-called “Two Bombs, One Satellite” ideology underpinning the Chinese state-led, top-down approach evolved from the success of the Chinese nuclear and space programmes in the 1960s and 1970s (Cheung 2009a, 238). The defence and civilian industries, and research institutes, were clearly separated, resulting in a closed defence sector. This state-led environment allowed the selective allocation of resources for major science and engineering projects. This principle of selectivity, still being emphasized by Deng Xiaoping, has lost some relevance with growing defence budgets (Cheung et al. 2016, 22).

The traditional characteristics of the PRC's defence industrial policy have to some extent been abandoned in the modernization effort. The Chinese DIS has seen a major overhaul in the last three decades, including the growing relevance of market forces following the commercialization of defence industrial enterprises. In the effort to catch-up to advanced economies, the modernization drive focuses on the absorption of foreign technologies and knowledge, as well as on "leap-frogging". "Leap-frogging" or "generation-leap" describes the idea of skipping phases of innovative evolution, thus overriding the slower path of incremental evolution (Bitzinger and Boutin 2009, 132; Cheung 2018c, 2).

More importantly, the success in catching-up with other nations increasingly enables indigenous innovation and lessens the utility of absorption. This has specifically become relevant in the 2010s. Beginning with the concept of civilian-military integration (CMI) announced in 2004, the government strives to break down the separation between civilian and defence sectors. The Ministry of Science and Technology (MOST) and the Commission on Science, Technology and Industry for National Defence (COSTIND) had already pursued the utilization of dual-use technologies since the late 1990s.

CMI emphasized the utilization of civilian dual-use technology by defence enterprises. This focus on technological "spin-on" specifically targeted technologies essential for informatized warfare (Bitzinger 2017, 60). The promotion of CMI under the Hu Jintao administration ran nonetheless into problems due to the lack of coordination within the administration, and shortcomings in the institutional framework regarding IPR, technology transfer, and industry standards (Cheung 2019, 599).

In 2014 the Xi Jinping administration replaced CMI with the national development strategy of military-civilian fusion (MCF), thus heralding the next phase in breaking down barriers. MCF puts emphasis on spin-on as well as spin-off, hence promoting two-way technology transfers. The strategy is aimed at completely integrating the two sectors, rather than just establishing links. It parallels the aforementioned rise of the Chinese defence industry from innovation follower to leader (Cheung 2019, 599).

Planning Instruments

The Chinese governmental utilizes a multi-faceted system of plans that centre on a mid-term five-year planning cycle, complemented by short-term one-year and long-term ten-year plans, and long-term stand-alone plans. In 2005, the government renamed its planning documents (although this does not reflect in English), indicating the switch from an interventionist to a guiding approach (Cheung et al. 2016, 3). One the national level, defence acquisition reform

and defence industrial policy are linked to the respective Medium- and Long-term National Economic and Social Development, and Science and Technology Development Plans.

The PLA's acquisition policies are formalized in the Weapons and Equipment Development Strategies (WEDS) and Weapons and Equipment Construction Plans (WECP). These draw from the Military Strategic Guidelines (MSG), which represent the highest level of defence policies. The MSG are rarely revised, on average only once a decade with the rise of a new chairman of the Chinese Military Commission (CMC) (Finkelstein 2007, 95). The WEDS and WECP are classified and developed in short-, medium-, and long-term versions, as well as on different levels.

Table 12 – The PRC's central defence acquisition planning documents (Cheung et al. 2016, 16–21; Cheung 2019, 602)

Name	Content	Level	Timeframe	
Weapons and Equipment Development Strategy (WEDS)	aligns defence requirements with overall national economic planning	national level; service branches	10 to 20 years	recurring plans
Weapons and Equipment Construction Plans (WECP)	implements the strategic requirements as defined by the WEDS	national level; service branches	10-, 5-, and 1-year versions	
Medium- and Long-Term Defence Science and Technology Development Plan	equivalent to the civilian MDP overarching document on measures to improve DIS dynamics	national level	15 years (2006 – 2020) (2021 – 2035)	
China's Defence Science and Technology to 2000	COSTIND roadmap for boosting Defence S&T	national level	15 years (1986 – 2000)	dedicated plans
2025 Defence S&T Industry Plan	parallel to Made in China 2025 dedicated funds for crucial defence industries	national level	10 years (2015 – 2025)	
“995” High-Technology Development Plan	selective development of asymmetric defence capabilities	national level	since 1999 implemented in 5-year phases	
“863” High-Technology Research and Development Plan	support of S&T development in strategic areas	national level	1986 – 2016	

The WEDS takes into account national-level planning, specifically the Medium- and Long-Term Plan for Science and Technology Development, and covers long-term planning for the whole defence establishment. The PLA service branches themselves also draft their own WEDS,

thus while the national version aims at jointness, the service branch versions often result in budget competition. While the PLA Navy (PLAN) developed its own WEDS since the mid-1980s, a national version was only created in the wake of organizational centralization in 2000.

The WECP are also drafted on both a national and service branch level. The plans outline the detailed implementation of the requirements set-out by the WEDS. The 10-year version stands at the top of this planning system, covering the whole defence acquisition system. It includes major development projects and policy reforms and is regularly updated. The five-year version is aligned to the overall five-year economic planning cycle. It specifies the policies for different steps of the R&D and acquisition process and defines resource allocations. The one-year version provides the details for the implementation of specific projects (Cheung et al. 2016, 16– 21).

Additional stand-alone plans were drawn-up by COSTIND in 1986 and 2006. Little is known about details of the China's Defence Science and Technology to 2000 roadmap, other than that it was a consensus document to guide the sector's development (Cheung et al. 2016, 20). It can be seen as precursor to the MLDP, which was created in 2006. The 2006–2020 Medium- and Long-Term Defence Science and Technology Development Plan (MLDP) was developed by COSTIND, mirroring the civilian Medium- and Long-Term Plan for Science and Technology Development (MLP). The MLDP outlines a vast number of measures affecting all facets of the Chinese DIS, thus outlining many of the reforms outlined below. Since its reformulation for another 15 years is anticipated, it then would become a recurring plan (Cheung et al. 2016, 24– 25).

In addition to the regular planning cycles, stand-alone plans have been implemented to pursue more narrow goals. These include the 995 High-Technology Development Plan and, although quite overarching, the 863 High-Technology Research and Development Plan. Complementing the Made in China 2025 plan, a 2025 Defence S&T Industry Plan was also announced in 2015, focusing on manufacturing in the defence sector (Cheung 2019, 594). Due to the increasingly integrated nature of the Chinese economy emerging in wake of the CMI and MCF policies, today the DIS also profits from general economic development programmes such as the Strategic Emerging Industries (SEI) initiative, and the Made in China 2025, 973 National Basic Research, and Torch Plans (Cheung et al. 2016, 25–29).

5.1.2. Organizations

Until the late 1990s, China's top-down steering approach was paralleled by a high degree of fragmentation in the form of branch specific DPA organizations. Although a former high-level leadership body, the Central Special Committee, was installed to direct major strategic projects

such as the nuclear weapon, sub-marine, ballistic missile and space programmes during the 1960s, the necessity of this body directly originated from the otherwise inefficient defence sector performance (Chase et al. 2015, 128–129).

While the People's Liberation Army (PLA) underwent continuous reforms and saw the creation of new branches, parallel efforts to reform procurement had repeatedly failed in establishing an effective and efficient DPA structure (Shambaugh 2002, 225–233). Since 1982, the Commission of Science, Technology and Industry for National Defence (COSTIND) was the most important player in the coordination of weapons systems production and linked facilities.

Reporting directly to the CMC and the State Council, COSTIND had been a merger of three organizations to centralize oversight and decision making. During the reform era, it had been tasked with implementing new policies and institutions to regulate the defence sector. At the beginning of the 1990s, the commission was not only superordinate to the “Ministries of Machine Building” that enveloped the defence industry, but also to twenty-nine educational facilities, including universities (Cheung 2009a, 49–93).

In 1991 defence procurement itself was still distributed amongst service branch specific bodies, who also oversaw S&T and R&D undertakings. In fact, only recently had the PLA's service branches themselves managed to establish central bodies to oversee research, development and production. These were coordinated by the CMC General Staff Department (GSD) (Cheung 2009a, 97–98).

The 1998 Overhaul

A major governmental and military reform finally established a single DPA in form of the General Arms Department (GAD), one of four overarching departments under the CMC, in 1998 (Shambaugh 2002, 143). The reform was part of a broader push to reorganize the government's oversight and control mechanisms for the defence industry and elevated the importance of defence innovation in the organizational hierarchy (Bitzinger and Boutin 2009, 133; Bitzinger 2016, 772).

The GAD was established as centralized planning and oversight body to manage the interface between the defence industry and essential users in the PLA branches (Shambaugh 2002, 239). Restraining its overhead role, GAD authority remained limited to the PLA Ground Forces, the People's Armed Police and the militia, since other branches retained separate procurement and armament agencies (Cheung 2013, 4). The branches thus continued to compete for budgetary resources, which impeded collaboration efforts (Chase et al. 2015, 129).

Overlaps in authority and the competition for budgetary resources also affected the cooperation between the GAD, the GSD and the CMC General Logistics Department (GLD) and impeded effective policy planning and resource allocation. In response to these problems the Strategic Planning Department was established in the GSD in 2011, with the mission to improve strategic management functions in the CMC. Reports indicated that it nonetheless continued to struggle with the reluctance of other departments to give up authorities (Chase et al. 2015, 129–130).

The second element of the organizational overhaul was COSTIND's separation in its civilian and defence parts, with weapons testing grounds, defence research institutes and space launch facilities handed to the GAD. Since COSTIND had previously been a part of the PLA itself, the armed forces had been both consumer and producer at the same time. This constellation prevented the introduction of market forces such as competition and the PLA's ability to choose between suppliers. It displays the move away from a classical supply-push innovation pipeline, towards the chain-linked innovation model.

The authority over drawing up and implementing policies, and managing the institutional framework remained with COSTIND, as did its superordination over universities. The defence SOEs on the other hand gained more liberty through commercialization. The reorganization allowed the PLA for the first time to independently draw on foreign suppliers, when the domestic DIB was unable to fulfil requirements (Cheung 2009a, 112–113). A separate New High-Technology and Engineering Leadership Small Group, mirroring the Central Special Committee of the 1960s, was also created in 1999, to coordinate the implementation of the 995-plan (Cheung et al. 2016, 27).

The unclear delimitation of authorities between GAD and COSTIND also resulted in further competition between these two organizations, necessitating a resolution to the redundancy (Crane et al. 2005, 165). In 2008, COSTIND was transformed into the civilian State Administration for Science, Technology and Industry for National Defence (SASTIND), subordinate to the major Ministry of Industry and Information Technology (MIIT). SASTIND continued its mandate to regulate the defence industry as civilian entity, now in coordination with the MIIT departments regulating the civilian market (Cheung 2009a, 116–117; Chase et al. 2015, 126).

The 2016 CMC Reform

In 2016 the CMC was again reorganized, addressing the limited authority of the General Arms Department and associated authority and linkage problems. The GAD was dissolved and instead an Equipment Development Department (EDD), as one of seven CMC departments, established (Bitzinger 2016, 782). The EDD is “mainly responsible for development and planning, R&D, testing and authentication, procurement management and information system construction for the whole military's equipment” (Yao 2016).

More specific construction and management tasks are still handled by the respective PLA branches themselves. The department hence took over authorities both from GAD and former COSTIND. The demands on defence R&D are derived from the military policies developed by the CMC Joint Staff Department and the CMC leadership, while the EDD is tasked with implementing these demands through R&D, development, planning, testing, authentication and procurement undertakings (Yao 2016).

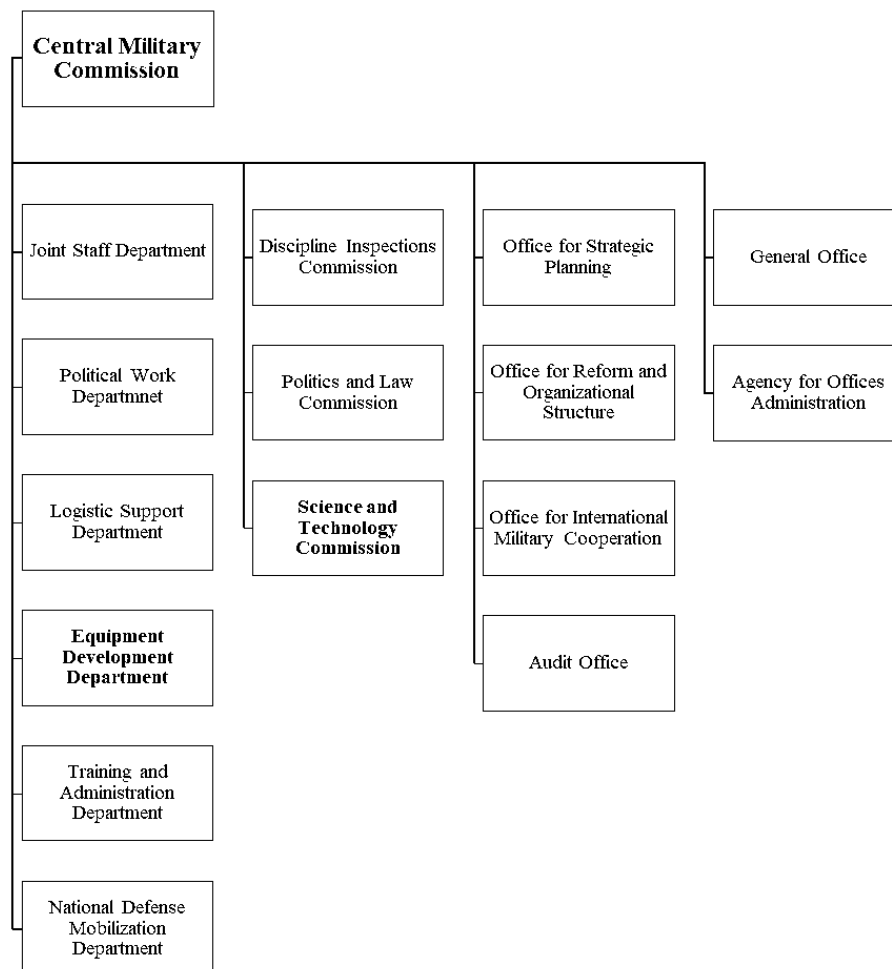


Figure 4 – The Central Military Commission (compiled from Ministry of National Defence of the People's Republic of China 2019)

The 2016 CMC re-organization also created three new commissions, one of them the Science and Technology Commission (STC). The STC is tasked with “accelerating the modernization of national defence and the armed forces ... strengthening the management of national defence science and technology, promoting independent innovation ... and pushing for the integrated development of military and civilian science and technology” (Yao 2016).

While the EDD coordinates R&D and procurement of defence products, the STC is responsible for preceding stages of the industrial life-cycle, such as managing science and technology projects, promoting innovation, and facilitating respective MCF undertakings. In contrast to the former GAD, the STC also has oversight over experimental and exploratory research undertakings. Together with the Ministry of Science and Technology (MOST), the STC is involved in promoting MCF for dual-use and key S&T projects (Cheung and Hagt 2019, 157).

In 2017, the CMC Military Science Research Steering Committee (MSRSC) was created as advisory body for both the CMC chairman and the STC. Foreign observers have drawn parallels between both the STC and the MSRSC to the US American DARPA, an international role model for disruptive defence innovation (Ni 2017).

The MSRSC’s exact role remains unclear, but it is expected to act as authoritative oversight body responsible for defining priority R&D projects and reforms under the MCF framework. While the creation of a permanent high-level entity may provide a boon to MCF efforts, the delimitation of authorities within the DIS remains unclear. The proliferation of entities with responsibility for the field since 2016 may in fact produce a new wave of bureaucratic gridlock (Cheung and Hagt 2019, 158).

Further organizations within the Chinese DIS include STC’s National Defence S&T Innovation Rapid Response Team, the CMC Office of Strategic Planning, and the PLA branches and Military Districts themselves. Their tasks primarily concern linkages and are further outlined in the respective sub-chapter 5.1.5. With the creation of the National Defence Intellectual Property Office in the early 2000s, the Chinese DIS also has a dedicated organization managing technology transfers and retention.

Civilian Organizations

On the civilian side, in 1991 defence industrial policy making involved the State Planning Commission (SPC) and the State Economic Commission (SEC), both bodies of the State Council. Together with COSTIND they formed the All-Country Defence Industrial and Technological Conversion Liaison Group, later known as Defence Conversion Liaison Office

(DCLO) or as China Association of Peaceful Uses of Military Industrial Technology (CAPUMIT).

COSTIND, the SPC, the State Science and Technology Commission (SSTC), as well as the Chinese Academy of Sciences were also managing the crucial National High-technology R&D Programme (863-plan) established in 1986. While COSTIND managed issues with high relevance for the defence sector, SEC and subsequently the State Economic and Trade Commission were responsible for foreign technology transfers (Cheung 2009a, 56). The same trio of COSTIND, SPC, and SSTC also collaborated on revising and drafting institutions for the defence sector (Cheung 2009a, 65).

The 1998 governmental reform also included the restructuring of civilian organizations, although in respect to authorities affecting the DIS it mostly involved the renaming of organizations. The SPC had become the State Development Planning Commission, while the SSTC was reformed in the Ministry of Science and Technology (MOST). The ministry has programme leadership of the central 863-plan and coordinates major S&T programmes, including those on dual-use technologies (Cheung 2009a, 191).

In 2003, part of the State Development Planning Commission became the National Development and Reform Commission (NDRC), while the other part merged with the State Economic and Trade Commission into the new Ministry of Commerce. Within the NDRC, the Department of Economic and Defence Coordination still takes a crucial role in the macro-economic planning of CMI/MCF implementation measures (Cheung and Hagt 2019, 156).

The management of state-owned enterprises including defence industrial enterprises has been consolidated in the State Council's State-owned Asset Supervision and Administration Commission (SASAC) in 2003 (Cheung and Hagt 2019, 156). As aforementioned, in 2008 COSTIND was transformed into the civilian SASTIND that continues to regulate the institutional framework of the defence sector. SASTIND is subordinate to the MIIT. The MIIT also includes a specific Department for CMI Promotion and chairs the Inter-Ministerial Coordinating Small Group for the Development of the (CMI) Weapons Research and Production System, a high-level body drawn from civilian and military departments that discusses CMI efforts (Lafferty 2019, 646–647).

In 2017, a special Commission for Integrated Civilian-Military Development (CICMD), headed by party chairman Xi Jinping, was founded to provide an authoritative body able to enforce MCF (Cheung 2018b, 35). The CICMD thus connects both relevant spheres of the bureaucratic system, the State Council and the Central Military Commission (Cheung and Hagt 2019, 155–

156). It appears to be designed to overcome the formerly dispersed authority structure in the civilian sphere, akin to the MSRSC. Since the aforementioned MIIT's CMI department and inter-ministerial coordinating group are drawn from departments at the same organizational level, the lack of a single authority had often prevented advances in the implementation of the CMI guidelines (Lafferty 2019, 648–649).

Further ministries involved include the Ministry of Finance, which oversees the financing of development projects and industrial parks (Cheung and Hagt 2019, 157). The Ministry of Education (until 1998 the State Education Commission) provides funding for universities involved in defence research and facilitates exchange programmes with the PLA and COSTIND/SASTIND (Cheung 2009a, 155–160). In collaboration with the Central Military Commission, the National Intellectual Property Administration, formerly the State Intellectual Property Office is involved in regulating patents and IPR, and facilitating technology transfers, including through the declassification of defence patents (Cheung and Hagt 2019, 157).

5.1.3. Actors

State-owned Enterprises

The Chinese DIB continues to be dominated by state-owned enterprises (SOEs) and the same top-down management approach as the DPA itself (Chase et al. 2015, 127). The DIB was characterized by a high degree of redundancy. This was a legacy of the “third line” strategy, under which strategic industries were also moved to the north-eastern and south-western provinces of China, in order to safeguard them from any Soviet attacks after the Sino-Soviet split (Joffe 1995, 26).

In 1991, the Chinese defence industry was organized into ministries, originating from the concept of “machine-building” ministries of the 1960s. Most important for the defence sector were the Ministry of Energy Resources, the Ministry of Aerospace, the Machine Building and Electronics Industry Ministry, and the Ship Construction Corporation (Frankenstein and Gill 1996, 400; Bitzinger and Boutin 2009, 132–133). Defence related research was conducted in research institutes subordinate to these ministries or by government controlled academic institutes (Bitzinger and Boutin 2009, 125–126).

In the early 1990s the Chinese government undertook reforms to “corporatize” and “marketize” the defence sector and decrease redundancy, and thus increase efficiency and innovativeness (Naughton 2018, 345). Between 1988 and the end of 1991, many smaller defence enterprises had been given to local administrations or civilian ministries, while others were merged or

closed (Cheung 2009a, 95). The restructuring also affected the overarching ministries, as they were “corporatized” into five state-owned enterprises (SOEs) in 1993. These new companies and the national military R&D programmes were de-facto subordinate to COSTIND (Bitzinger 2017, 51).

The renaming had little impact on the actual performance of the new companies, as they continued to behave as government bureaucracies (Cheung 2009b, 39). Because of the defence sector’s nature as strategic industry, the defence SOEs also remained under much stricter governmental oversight than other SOEs. This prompted the government to sustain unprofitable enterprises and to cover cost overruns, which in turn continued to impede the innovativeness of the sector (Bitzinger and Boutin 2009, 137–138).

Table 13 – Chinese defence SOEs in 1993 (Bitzinger 2017, 51)

Name	Abbreviation
Aviation Industries of China	AVIC
China Aerospace Corporation	CASC
China Ordnance Industry Corporation	NORINCO
China State Shipbuilding Corporation	CSSC
China National Nuclear Corporation	CNNC

The 15th Communist Party Congress in 1997 decreed a further fundamental restructuring and down-sizing of SOEs, encompassing also the defence sector (Bitzinger and Boutin 2009, 132–133). During the 9th National People’s Congress in the subsequent year, these changes were developed in detail. They entailed the reorganization and consolidation of the Chinese DIB into ten overarching defence industrial enterprise groups (DIEGs), which was accomplished by 1999.

The DIEGs were designed as conglomerates encompassing the whole industrial life cycle, from R&D, to production, and marketing. In an effort to increase their innovativeness, the new entities received more independence and budget responsibility, and were intended to compete with each other (Bitzinger and Boutin 2009, 133–134). Another noteworthy SOE is the China Poly Group Corporation. The corporation is a major trading house that is not only active in the arts and real estate fields, but it also undertakes arms exports through its subsidiary Poly Technologies (PolyTech) (Kirchberger and Mohr 2019, 45–47). The company develops, to a limited extent, weapon systems, but engages in arms trades, often to circumvent sanctions. It was in turn sanctioned by the United States in 2013 (Nunns 2013).

Table 14 – China’s ten defence-industrial conglomerates in 1999 (Cheung 2009a, 120–122)

Defence Industrial Enterprise Group	Abbreviation	Domain
China Aviation Industry Corporation I	AVIC I	Larger military aircraft as well as commercial airliners
China Aviation Industry Corporation II	AVIC II	Smaller military aircraft, trainers, helicopters, transport aircraft
China North Industries Group Corporation (China Ordnance Industries Group Corporation)	NORINCO	Tanks, armoured vehicles, artillery, ordnance
China South Industries Group Corporation (China Ordnance Equipment Group Corporation)	CSGC	Ordnance, automobiles, motorcycles
China State Shipbuilding Corporation	CSSC	Destroyers, frigates, commercial ships
China Shipbuilding Industry Corporation	CSIC	Destroyers, commercial ships
China Aerospace Science and Technology Corporation	CASC	Space vehicles, satellites, missiles
China Aerospace Science and Industry Corporation	CASIC	Missiles, electronics and related equipment
China National Nuclear Cooperation	CNNC	Nuclear weapons and civilian nuclear programmes
China Nuclear Engineering and Construction Corp	CNEC	Nuclear power plants and defence infrastructure

The 1999 reform also included a reorganization of R&D within the Chinese DIB. This entailed the absorption of research facilities into the DIEGs, in order to end the compartmentalization between different stages of the industrial life-cycle. Since no dedicated DIEG for the electronics sector existed, 47 research institutes and 25 state-owned enterprises were merged to form the China Electronics Technology Group Corporation (CETC) as 11th DIEG in 2002 (Kirchberger and Mohr 2019, 47; Cheung 2009a, 148).

Contrary to the intentions of the 1999 reform, the DIEGs did not transform into entities comparable to international defence companies such as Lockheed Martin or BAE Systems. While these foreign conglomerates directly compete along the whole spectrum of military products, the Chinese conglomerates continue to focus on specific product fields. With exception of the shipbuilding industry, competition remains the exception rather than the rule. The merger of the two aircraft DIEGs AVIC I and II in 2008 in fact led some observers to subsume that China had given-up its competition model (Bitzinger and Boutin 2009, 137).

Although the re-merger of the aviation industry was a setback from previous reforms, it appears to have been necessary due to the high redundancy between the two DIEGs and the resulting damage to their competitiveness (Cheung 2009b, 41–42). In 2018 the China National Nuclear Corporation and the China National Engineering Corporation were re-merged as well, with some observers also expecting a future merger of the two shipbuilding DIEGs (Cheung 2019, 598).

Presenting the uppermost layer of the Chinese DIB, the DIEGs continue to have monopolies, rather than the envisaged duopolies in their defined defence industrial sectors (Chase et al. 2015, 127). Some researchers also list other industrial SOEs as DIEGs, but while relevant to the Chinese DIB, these are not classical defence companies (e.g., Levesque and Stokes 2016, 52; Joske 2019, 20). The organization of the Chinese DIB into DIEGs nonetheless shrouds the true extent of the defence sector. The DIEGs function as holding companies for a vast number of subsidiary firms and research institutes (Kirchberger and Mohr 2019, 46–47).

Table 15 – Evolution of the Chinese state-owned DIB 1991 – 2020

1991	1993	1999	2020
Ministry of Energy Resources	China National Nuclear Corporation	China National Nuclear Cooperation China National Engineering Corporation	China National Nuclear Cooperation
Ministry of Aerospace	Aviation Industries of China China Aerospace Corporation	China Aviation Industry Corporation I China Aviation Industry Corporation II China Aerospace Science and Technology Corporation China Aerospace Science and Industry Corporation	China Aviation Industry Corporation China Aerospace Science and Technology Corporation (space) China Aerospace Science and Industry Corporation (missiles)
Machine Building and Electronics Industry Ministry	China North Industries Group Corporation	China North Industries Group Corporation China South Industries Group Corporation	China North Industries Group Corporation China South Industries Group Corporation
Ship Construction Corporation	State Ship Construction Corporation	China State Shipbuilding Corporation China Shipbuilding Industry Corporation	China State Shipbuilding Corporation China Shipbuilding Industry Corporation
	Ministry of Electronics Industry (civilian)		China Electronics Technology Group Corporation (2002)

Defence Universities

Aside from the research institutes subordinate to the DIEGs, defence research is also conducted by the “Seven Sons of National Defence”. These are seven universities subordinate to COSTIND/SASTIND that have been characterized as defence universities (Joske 2019, 6–7).

Table 16 – The “Seven Sons of National Defence” (Joske 2019, 6)

Universities	Fields of Defence Research
Beijing Institute of Technology	Armaments and aeronautics
Beijing Aeronautics and Astronautics (Beihang) University	Aeronautics and astronautics
Harbin Engineering University	Maritime technology, nuclear, aeronautics, astronautics and armaments
Harbin Institute of Technology	Aeronautics and astronautics
Nanjing University of Aeronautics and Astronautics	Aeronautics and astronautics
Nanjing University of Science and Technology	Armaments
North-western Polytechnical University	Aeronautics, astronautics, maritime technology and armaments

In addition to the SASTIND universities, the PLA also has three internal universities that undertake defence research: The PLA National University of Defence Technology, the PLA Information Engineering University, and the PLA National Defence University (Cheung 2009a, 157–159).

Civilian and Private Enterprises

Since the 1990s, the PLA has strived for intensifying its outreach to non-traditional enterprises in the private sector (Bitzinger 2016, 774). Four major civilian companies had become involved in the defence sector through invitation in the late 1980s, due to the relevance of their dual-use technologies: Huawei Technologies, Great Dragon Telecommunications Equipment Corporation, ZTE Corporation and Datang Telecom Technology Corporation (Cheung 2009a, 215).

From the 2000s onwards, the breaking down of barriers between civilian and military sectors had somewhat accelerated under the CMI framework. Under the Hu Jintao administration, the push for “overall coordination” did not fulfil expectations due to the continued lack of regulations, IPR for inventions in the defence sector, and a shortfall in the collaboration between affected public bodies (Cheung 2019, 599). By 2011, still only about 1% of high-technology enterprises were involved in defence contracts (Cheung 2011a, 343–344).

Since the introduction of MCF, the integration of non-traditional suppliers into the Chinese DIB has rapidly accelerated (Cheung 2018a, 2). Civilian enterprises in the electronics, information technology, high-technology, and automotive sectors, and companies with expertise in strategic subsectors are now considered part of the DIB. Civilian industries are increasingly involved in public defence R&D projects and production lines. This includes the collaboration with prominent high-technology enterprises (Boutin 2017, 41). Civilian and defence companies have established extensive networks, specifically in the MCF clusters.

The progress in CMI/MCF makes an overview of all private enterprises involved in the Chinese defence sector unfeasible. In wake of the CMI and MCF policies the historical delimitation between the state-owned defence sector, and the civilian and private sectors, has increasingly broken down. Much emphasis is given to utilizing private R&D for developing dual-use products. By 2018 more than new 16 000 entities had registered on the PLA's Weapons Acquisition Information Network (WEIAN), where procurement tenders are published (Cheung and Hagt 2019, 159).

5.1.4. Institutions

Ownership and Investment Regulations

By 1993, as aforementioned, corporatization of defence SOEs was initiated through a new Corporate Law. The defence industry was transformed into DIEGs in two stages in 1993 and 1998. The new DIEGs nonetheless remained “closely-held corporations”, establishing a board of directors and a chief executive officer, but no shareholder meeting (Aivazian, Ge, and Qiu 2005, 794). The 1999 Securities Law further enabled and expanded possibility of stock market listings of SOEs. In the third SOE reform stage, starting in 2003, the issue of ambiguous ownership was tackled. Major, strategic SOEs such as the DIEGs were retained and given to the newly found State-owned Assets Supervision and Administration Commission (SASAC), while smaller ones were given to local governments (Lin et al. 2020, 38).

In 2009 SASAC's authority and mandate was clarified through the Law on State-Owned Assets in Enterprises. While the law limited government interference and strengthened investor functions, it allows the State Council to decide issues of merger, separation, dissolution, bankruptcy in strategic industries such as defence (Law of the PRC on State-Owned Assets in Enterprises 2008, Art. 34). It also prevents the sale of SOEs with national security relevance to overseas investors (Art. 57).

The subsequent, ongoing reform stage was initiated by the 12th Chinese Communist Party (CCP) Congress in 2012. It was formalized in one policy document, the 2015 “Guiding Opinions on Deepening the Reform of State-owned Enterprises”. SOEs are distinguished by commercial and public-service classifications. Strategic SOEs, a sub-category of commercial ones, are only selectively supported by the central government. Thus, the government may now shift resources to public-service SOEs. Nonetheless strategic commercial SOEs retain increased protection and support, compared to full competitive commercial SOEs. At the same time, SOEs have to integrate CCP leadership into their decision making (Lin et al. 2020, 38–39).

While highly relevant, the SOE reform and linked legal reforms only partially display the undertakings in the delicate area of defence. Opening steps have primarily been driven by COSTIND/SASTIND and its policies, which often lagged behind those for less strategic SOEs. Throughout the 1990s and early 2000s, the Chinese defence sector had been firmly in the hand of the state. First organized in ministries, the defence sector was as aforementioned reformed into SOEs in 1993 and DIEGs between 1997 and 1999 (Bitzinger and Boutin 2009, 132–134). Although the DIEGs and their predecessors were permitted to list subsidiaries on the stock markets in China and Hong Kong from the early 1990s onwards, this was limited to civilian firms (Cheung 2019, 605).

Further restructuring of the DIEGs towards a mixed-ownership model through stock market listings was envisaged (Peng 2004, 96). While this was slowly been implemented in the civilian SOE sector, since the creation of SASAC in 2003, the introduction of a mixed-ownership model in the defence sector only started taking shape after 2006 (Zheng 2014, 43). Initiated in 2007, an institutional framework for DIEG stock market listings was developed by COSTIND. Despite the support of high military cadres for a mixed-ownership model that would further innovation, the government had been reluctant to decrease its control. Therefore, mix-ownership and stock market listings continue to primarily target subordinate enterprises (Yang 2017). Although some observers see no direct governmental authority over the DIEGs, the Communist Party itself de facto controls them (Cheung and Hagt 2019, 159).

In 2007 alone, COSTIND produced five guidelines and regulations to that end. These allowed the inflow of private capital into the defence industry, the access of the defence industry to capital markets, and the first initiative to diversify ownership and investments in the defence sector. The latter became available through the options of shareholding, mergers, and acquisitions. Although the implementation of ownership reforms was delayed by the financial crisis 2008/2009, it picked-up speed afterwards. The aviation and shipbuilding industries were

the first to profit from the reforms. Five further guidelines and regulations were drafted by SASTIND between 2010 and 2016. These included further ownership reforms for defence enterprises and research institutes, the access of private entities to weapons R&D, and the securitization of military assets (Cheung 2019, 605–607).

Table 17 – Important Ownership and Investment Reforms 2007-2016 (Cheung 2019, 606)

	Guidelines / Regulations	Important Content
2007	Guiding Opinions from COSTIND Regarding Non-Public Ownership Economic Participation in Construction of Defence S&T Industry	Encouragement for: 1) Private capital for defence S&T, 2) Acquisition of shares, shareholding, merger and acquisitions, for developing dual-use products with focus on the civilian market
	Guiding Opinions Regarding the Development of Defence S&T Industry for Civilian Industry	Encouragement for: 1) utilization of capital markets, 2) gaining capital through acquisitions, asset swaps, joint ventures, 3) defence enterprises selling products on the civilian market
	Certain Opinions Regarding Deepening Reform of Investment System for Defence S&T Industry	Diversification of investment/ownership of defence S&T enterprises Definition of open, restricted, prohibited classes
	Guiding Opinions Regarding the Promoting Shareholding System Reform for Defence S&T Industry	Finalization of shareholding reform and establish modern enterprise and ownership structures
	Interim Measures for Implementation of Shareholding Reform for Defence Enterprises	Permission for the reacquisition of defence enterprises by domestic actors
2010	Certain Opinions Regarding Establishment and Improvement of Civil-Military Integration of Weapons and Equipment Research and Production Systems	Shareholding reforms through asset structuring, listing, mutual shareholding, merger and acquisitions Reform of defence R&D actors, restructuring to modern enterprise structures or large corporate R&D centres
2012	Implementation Opinions for Encouraging and Guiding Private Capital in Entering Defence Industries	Encouragement of private R&D for weapons and equipment Utilization of private capital for restructuring defence enterprises and dual-use R&D
2013	Rules for Defence S&T and Industry Fixed Assets Investment Program Management	Permission for large share placements, utilizing military assets as securitization
2014	Guidelines on Promoting Civil-Military Integration	Further easing of private capital introduction
2016	Related Issues for Non-State Owned Enterprises Applying for Military Industrial Fixed Assets Investment Programs	Regulations for private actors to invest in fixed assets of defence industry

By 2012, considerable numbers of DIEG subsidiaries were listed on stock markets in Hong Kong and Shanghai, but their mother companies were still completely owned by the

government (Lague and Zhu 2012). Until 2018, the DIEGs had listed 100 subsidiaries on domestic stock markets, compromising 33 percent of their assets (Cheung and Hagt 2019, 153).

While the reforms have diversified the ownership structure of the defence industry, research institutes subordinate to the DIEGs were still excluded from private investment. They could not be listed on stock markets or securitize their assets. After 2016, SASTIND thus introduced three documents outlining future liberalization. The goal of these reforms are an increase of efficiency and resource allocations, boosting the further implementation of MCF.

Akin to the definitions for the defence industry in 2007, research institutes are divided in open, restricted, and prohibited classes that define potential ownership structures. After consultations with the DIEGs, the aerospace industry will be the first to reform its research institutes (Cheung 2019, 602–603). In 2017, a first reform wave that will comprise of 41 research institutes was initiated (Cheung and Hagt 2019, 153).

Foreign investment on the other hand was still strictly regulated through a governmental approval process. Since 2011, China has implemented a formal national security review for foreign investments. Until 2016, the regulatory regime was implemented through a case-by-case review. Between 2016 and 2020 a gradual liberalization was implemented. Nonetheless, defence enterprises remained on the list of prohibited sectors excluded from foreign investments.

Complementing the new Foreign Investment Law of 2020, the new Measures for the Security Review of Foreign Investments were implemented. For the first time, investments in the DIB became possible, pending on a review conducted by NDRC and the Ministry of Commerce. Investments may only be approved, if they do not have an impact on national security. The same review is also applied for investment proposals in the IT sector (Bian 2021).

Defence Market Entry Regulations

For decades, access to defence contracts and defence-related R&D had been blocked for civilian and foreign enterprises, as well as civilian universities, due to the armed forces' concerns regarding secrecy (Cheung 2009a, 89). Both the participation in projects and the direct application for defence contracts was forbidden, although some exceptions for critical equipment were created. One example was Huawei, being able to supply critical equipment and develop close links to the PLA due to high-level governmental support (Cheung 2009a, 216).

COSTIND began the process of slowly opening the sector to private participation in 2005. In frame of the “Measures to Implement Permission for Weapons Equipment Research,

Development, and Production” regulation, for the first time private and foreign enterprises were allowed to apply for licences permitting their participation in the defence economy.

In parallel, the MIIT also opened defence electronic projects to the private sector. Licences became available for category 1 (advanced weapons and high technology) and category 2 (subsystems and auxiliary work) projects. While only SOEs were eligible for category 1, both private and foreign companies could receive category 2 licences. Nonetheless, applying enterprises had to conform to strict technological, financial and secrecy regulations (Cheung 2009a, 188–189).

As outlined in Table 17, subsequently the defence sector was further opened to private participation through shareholding, joint ventures and investments. Since 2012 private enterprises can directly participate in weapons R&D undertaking. Between 2012 and 2016 more than 1000 private companies, presenting about 40 percent of defence contractors, gained licences to develop military equipment (Yao 2017a; Levesque and Stokes 2016, 23). In an outreach to the civilian sector, in 2015 the EDD created the web portal “Weapons Acquisition Information Network” (WEIAN) that provides both information and procurement notices (Cheung and Hagt 2019, 159).

In 2017, CMC EDD published new guidelines aimed at liberalizing and regulating defence procurement, thus enabling more private entities to apply (Zhang 2017; Huang 2017). It also introduced a programme listing 2000 equipment and weapons projects open for private entities (Yao 2017a). By 2019, two thirds of the civilian companies with defence licences were private entities. Private companies are also increasingly involved in category 1 undertakings (Levesque 2019, 12). Nonetheless, the PLA is still reluctant to involve private enterprises in its larger and more sensitive projects, which would demand additional legal clarifications regarding secrecy (Béraud-Sudreau and Nouwens 2019, 12).

Intellectual Property Rights

China created a separate defence patents system in 1985. The limitations this system created presented a major problem for the Chinese DIB throughout the 1990s. On the one hand, since the government funded all relevant research, all IPR fell into its ownership after R&D projects were finished. This discouraged actors to commit and follow-up on their findings after finalizing their projects (Cheung 2009a, 90). On the other hand, the lack of IPR regulations, and the armed forces’ insistence on classifying research results, prevented technological diffusion and collaboration within the defence sector as well as the overall economy (Cheung 2009a, 106).

It also provided an obstacle for researchers to profit from their work, thus negatively impacting incentives for recruitment and retainment of personnel, as outlined in chapter 5.1.9 (Cheung 2009a, 143). While a new general patent law was introduced in 1993, it had little impact in alleviating the defence sector's problems (Cheung 2018b, 20).

Subsequent to the 1998 organizational reform, attention shifted to the problems related to IPR and patents. In 2004 the “Regulations on National Defence Patents” were published in collaboration of COSTIND and the CMC (Cheung 2009a, 134). Additionally, a dedicated State Defence Patent Agency was established, which appears to be the current National Defence Intellectual Property Office (NDIP), subordinate to the CMC's Equipment Development Department (Cheung 2009a, 144).

The promotion of MCF has given defence patent management a further push. In 2017, EDD published the “Requirements on IPR Management for Equipment Manufacturers”, the first military standards for IPR management. Based on the “National IPR Management Specifications for Companies”, the regulations are designed to provide a clear framework for IPR in defence R&D, production, and tendering and bidding (Ouyang 2017).

In the same year, NDIP for the first time declassified more than 3000 defence patents, 2345 of them for the public, on the PLA's WEIAN web portal (Yao 2017b). In 2018, another batch of 4038 defence patents followed (Wang and Zou 2018). An analysis of the patents declassified in 2017 shows that findings in the fields of space, IT and missile technologies remain protected classified. Other fields can be freely used by the private sector, thus promoting spin-off technologies (Nouwens and Legarda 2018, 10). To improve accessibility, the NDIP also reduced its fees for defence patent registration in 2020 (Li and Wang 2017).

Arms and Technology Export Control

Until 1997, China had no specific export control law for defence material, instead relying on executive orders to approve arms exports. These were guided by the principles of supporting legitimate self-defence, the preservation of peace in the target region, and the prohibition of interference in domestic affairs. This reliance on executive orders and guiding principles left plenty of room for political considerations. Building on the 1994 Foreign Trade Law, in 1997 these three principles were codified in the “Regulations on the Administration of Arms Export”.

Arms export decisions were still determined in an inter-agency coordination process, with the State Administrative Committee on Military Product Trade (SACMPT) at its centre. Subsequently to SACMPT's abolishment in 1998, COSTIND and GAD became the main

players in this process (Medeiros and Gill 2000, 24–37). Especially the latter was the main actor enforcing Article 4 of the regulation, which bans any export of weapons that would harm national interests or security (Ministry of Commerce of the PRC 1998). This essential clause was already included in the 1994 Foreign Trade Law (Medeiros and Gill 2000, 52).

The Chinese defence sector had profited from its previously ambiguous export regime, as sales provided additional funds for military modernization. Until 2002, China only had a regulatory regime for the import of technologies, not for their export. The “Technology Import and Export Administrative Regulations” put in place in 2002, were the first measure to safeguard Chinese innovation achievements and implement proliferation controls.

The regulations specifically targeted defence, WMD, and dual-use technologies and utilize an export licence system (Yuan, Saunders and Lieggi 2002, 155–158). The regulations were amended in 2008 and 2020, the latter targeting 23 technology areas, including dual-use fields such as drones, lasers, encryption and 3D printing (Zeldin 2008 and Leng 2020).

Despite the creation of this legal framework, Chinese arms exports are not only regulated by these laws, but sometimes still by regulations, ministerial decrees and temporary ad-hoc export licence requirements (Li and Matthews 2017, 18–19). Since 2019, the National People’s Congress has started drafting a new law with tighter controls for conventional arms and nuclear technologies, an attempt to further consolidate the export regime. While emphasis is placed on China’s international responsibility, the associated blacklist for banned exporters will also include those that endanger national security through their sales (Elmer and Xie 2019).

China’s political ambiguity on arms export control is displayed by the hesitance with which the country has acceded to international control regimes. So far China is signatory only to the Nuclear Suppliers Group (2004) and the Arms Trade Treaty (2020), thus acceding to both rather late.

5.1.5. Policy Portfolio: Linkage Policy

Improving linkages within the defence, and later with the civilian sector, has been a primary element in all reform efforts since 1991. During the 1990s, high levels of compartmentalization were a main characteristic of the Chinese DIB and DIS. The lack of information flows resulted in a situation, where the defence industry often could not supply the military specifications demanded by the armed forces. Manufactories were regularly supplied with blueprints developed by R&D facilities that the workforce was unable to implement (Cheung 2009a, 90–91).

Even by the late 1990s, this meant that only 15 percent of research results were utilized in development and a scarce 3 percent finally led to the production of new equipment. While this problem was also due to the lack of financial incentives, and an unclear IPR system, the segregation of research, development and production entities was the main driver (Cheung 2009a, 142–143). Beyond that, the separation of defence undertakings from the civilian economy, adding additional layers of duplicity and redundancy, aggravated efficiency problems (Cheung 2009a, 106).

Linkages within the defence sector were dependent on a system of military representative offices (MRO), which were distributed throughout the DIB and the military hierarchy. In theory, the MRO system provided an extensive network to facilitate links, tasked with coordinating expertise, resources and knowledge providers. In practice, the assigned cadre often lacked the knowledge and insight to advance projects. Lacking opportunities for career advancement, and the financial dependency on the enterprises and institutes, also created a loyalty to the actors rather than the armed forces.

Since the 1980s, COSTIND had provided a system of knowledge databases, a S&T information centre, and a report system, but these measures were insufficient to overcome the lack of meaningful networks (Cheung 2009a, 96–97). COSTIND itself lacked direct links to the civilian economy, which obstructed early attempts of CMI. Coordination was thus limited to the aforementioned liaison group with the State Planning and State Economic Commissions (Cheung 2009a, 49–56).

The creation of GAD in 1998 for the first time established a central actor facilitating links between internal PLA facilities and the defence industry, including the ability to provide support with funding, personnel and technology (Cheung 2009a, 166). The reduced oversight role of COSTIND, implemented through the same reform, gave defence enterprises more independence to develop their own links in and outside of the DIB. The overhead DIEGs took over the role of coordinating and providing resources to their vast number of subsidiary enterprises and institutes (Cheung 2009a, 165–166).

While the defence sector was as reluctant to create ties with civilian universities and private enterprises, links between the two areas have intensified alike (Cheung 2009a, 89). Since the late 1990s the DIEGs have established joint-venture R&D partnerships with civilian universities and research institutes. COSTIND and PLA universities have intensified collaboration with their civilian counterparts, including exchange programmes. Both defence

enterprises and the PLA have deepened existing partnerships with the Chinese Academies of Sciences and of Engineering (Cheung 2009a, 205–209).

COSTIND also collaborated with leading universities to set-up national-level defence R&D laboratories (Cheung 2009a, 153). The number of such laboratories has especially grown since introduction of the MCF policy, with more than 150 universities being accredited for defence R&D in 2019 (Joske 2019, 9).

The implementation of CMI and later MCF meant that both the defence and civilian sectors were encouraged by the government to independently deepen their links with each other. An important policy instrument in this context are the “Strategic Cooperation Framework Agreements” (SCFAs) that SASTIND signs with other governmental entities since 2012. These SCFAs have been signed with provincial and local governments to develop clusters and MCF demonstration zones, which present essential hubs for creating new networks. SCFAs have also been signed with the All-China Federation of Industry & Commerce to develop incentive programmes for private enterprise participation in the defence sector.

Since 2015, MCF expos have been co-sponsored by DIEGs and public actors to enable both defence and civilian enterprises to showcase technologies with relevance for defence (Levesque and Stokes 2016, 22–23). Beyond showcasing their products, these provide a venue for networking and have proliferated throughout China, with every major cluster or demonstration zone hosting their own (Cheung and Hagt 2019, 160).

The STC has created a “National Defence S&T Innovation Rapid Response Team” in Shenzhen that will identify dual-use technologies on the ground in the high-technology cluster there. Another CMC entity, the CMC Office of Strategic Planning also houses an MCF Bureau tasked with overseeing and coordinating the PLA’s efforts on military-civilian fusion with civilian departments. (Cheung and Hagt 2019, 157–160).

Beyond those central bodies, the PLA branches themselves have signed their own cooperation agreements with universities and enterprises. This specifically applies to the PLA Strategic Support Force in context of its tasks in space, cyber and electronic warfare. The PLA Provincial Military Commands (PMC) take an important role through their Military Districts, as they are the part of the PLA with the strongest ties to local governments (Cheung and Hagt 2019, 157). The PLA Military Districts have become involved in facilitating and managing the new CMI/MCF industrial zones created since 2010 (Levesque and Stokes 2016, 29).

Recent years have also seen the emergence of local intermediary organizations that facilitate MCF. While these entities are heterogenous in their nature, existing in both public, mixed, and private legal forms, in general they employ experts or former military personnel from defence procurement and acquisition fields. These new organizations thus provide information and advice to local industries, and support civilian entities in entering defence contracts (Cheung and Hagt 2019, 160–161; Kania 2019, 23).

Foreign Linkages and Collaboration

Although Chinese strategies build on self-sufficiency as a core element, the PLA has utilized foreign technology transfers to make up for domestic shortcomings. Such transfers have been determined as a tool for the absorption of crucial technologies into domestic R&D (Cheung 2009a, 137). Throughout the 1990s, these transfers were mostly unidirectional, rather than building on lasting cooperation (Bitzinger and Boutin 2009, 127).

While the opening-up of China and the economic reform policy had enabled the Chinese DIB to develop ties to suppliers of knowledge and technology in the West, the sanction regime implemented in 1989 cut down such exchanges. In response to this shift, links to Russia, Israel and other non-Western partners gained in importance (Cheung 2009a, 91–92). While the Chinese DIS was primarily absorptive in 1990s and early 2000s, advancing through foreign technology transfers, it has shifted since towards a much higher degree of indigenous innovation (Cheung 2018c, 2).

Several avenues were developed to facilitate foreign technology transfers. These include technical and advisory consultations through inviting foreign scientists and researchers, especially from former Soviet states. Another was the off-the-shelf purchase of military systems, subsystems and components for re-engineering, and of production licences in areas where the Chinese DIB lacked sophistication, such as in aerospace technologies.

The relationship with Russia deepened in the early 2000s, after the two countries declared a strategic partnership in 1996. It paved the way for joint design and development with Russian firms. The cooperation with Russia was nonetheless negatively impacted by Chinese attempts to adapt and copy Russian weapon platforms. Indeed, the various forms of cooperation with Russia and reverse engineering did not fulfil expectations, due to the lack of knowledge in the relevant sectors of the Chinese DIB (Cheung 2009a, 137–141).

Despite the continuing arms embargo, Chinese defence enterprises were also able to collaborate with the European industry by exploiting loopholes regarding dual-use technologies. This was

facilitated both through joint-ventures and receiving production licences, with a considerable increase between 2011 and 2016 (Stanley-Lockman 2017, 71). Both civilian and defence universities, as well as the DIEGs, are also involved in exchange programmes with foreign universities. These do not only involve students, but also scientists employed in the defence sector. Cooperation countries are the United States, European countries, as well as Russia and Ukraine. Chinese defence enterprises were also able to establish joint laboratories focusing on dual-use technologies with a number of foreign universities, most importantly in the UK, but also in Australia, Germany, Austria and Switzerland (Joske 2019, 15–16).

The Chinese government furthermore employs a massive industrial espionage programme, which is tasked with acquiring defence and dual-use technologies from firms in the United States, Western Europe, but also Russia (Cheung 2009a, 137–141). Industrial espionage presents a viable tool for the CMI policy, enabling technological leapfrogging without the costs associated with indigenous research (Wortzel 2014, 22). Nonetheless, official commercial ties appear to be more important for boosting indigenous Chinese R&D than espionage (Boutin 2017, 43–44). Foreign enterprises investing in China are also confronted with forced technology transfers in order to gain market access (European Commission 2021a, 20).

5.1.6. Networks

Agglomerations

Due to the Third-Line policy, at the beginning of the 1990s major parts of the Chinese DIB were located in the country's South-western and North-eastern provinces. Sichuan and Chongqing, as well as Shaanxi and Guizhou, were the centre of China's defence industry and housed the majority of electronics and aerospace factories. Gansu on the other hand still is the home of the country's nuclear weapons programme and Liaoning the centre of its shipbuilding industries (Bachman 2001, 278–279).

By the late 1990s, about 55 percent of the Chinese DIB was still located in these areas, although vastly underperforming compared to the factories in coastal provinces. Already since the beginning of the decade the government had encouraged and funded Third Line industries to relocate to coastal areas (Frankenstein and Gill 1996, 403). Since the 9th Five-Year Plan (1996–2000) relocation of defence industries and integration with civilian high-technology enterprises has been part of defence industrial reforms (Walsh and Francis 2011, 2).

This immense undertaking was at best slowly progressing, hindered by the aforementioned immense concentration of assets in the inland provinces. The focus of economic development

and the presence of high-technology enterprises in coastal areas, and the pronunciation of civil-military integration, have given boost to the relocation. Defence enterprises located in coastal areas, such as IT and shipbuilding, displayed a better performance than their counterparts. Defence industrial policies have thus outlined the creation of defence-specific investment zones that are mirroring the successful civilian economic development zones and S&T parks (Walsh and Francis 2011, 3–5).

By 2018, about 74 percent of newly established subsidiary companies in coastal China were subsidiaries of defence enterprises from the Sichuan-Chongqing cluster. The classical defence industry is integrating into the already existing special economic and development zones. This conforms with the goals of civilian-military integration/fusion, overcoming the previous clear-cut geographical delimitations (Kirchberger and Mohr 2018, 44).

Clusters

While de-facto clusters may have existed within the classical agglomerations in Western China, there was no dedicated cluster policy. During the 2010s, the majority of Chinese provinces and major cities has founded new S&T parks and created funds to promote MCF within their districts. Presenting a detailed list of defence clusters within China is hardly possible. Noteworthy clusters for emerging technologies have developed in coastal cities, most notably Beijing, Shanghai, Tianjin, Qingdao and Shenzhen.

In Beijing this development is centred on the Zhongguancun high-technology zone with its 600-member strong Zhongguancun Military-Civil Fusion Industry Alliance that was founded in 2013. Since 2018, Zhongguancun is also home to a MCF Industrial Park. In Shanghai, the PLA National University of Defence Technology is cooperating with the local government to create a MCF innovation park in the city's Shunde district.

In Tianjin as well, the city is creating an Artificial Intelligence MCF Innovation Centre in vicinity of the National Supercomputer Centre. In 2017, an Underwater Vehicle Intelligent Equipment Base was founded in Qingdao, emphasizing the city's role as centre for maritime technologies. A year later, the West Coast New District was also created for aerospace, advanced materials, and maritime technologies.

While there is no dedicated MCF zone announced in Shenzhen yet, the special economic zone is the base of high-technology IT companies within China. As aforementioned, the importance of this cluster has led to the establishment of the STC's first "National Defence S&T Innovation Rapid Response Team" there (Kania 2019, 21–23; Levesque 2019, 14). With more than 350

research centres and industrial institutes, and 1700 high-technology enterprises, Wuhan as well has become a high-technology cluster and centre for the new defence industry (Chan 2020).

Under the auspice of SASTIND, a plan for ten sector-specific national hubs has been drawn-up. These hubs conduct leading research, and support decision-making and policy formulation at the national level. These hubs will include a Defence Science and Technology Innovation Centre, the Maritime Defence Technology Innovation Centre and the Strategic Rocket Science and Technology Defence Innovation Centre (Béraud-Sudreau and Nouwens 2019, 13).

Between 2009 and 2018, local governments have created 36 MCF demonstration zones in 22 provinces and municipalities (Cheung and Hagt 2019, 160). These zones complement eight regional “Comprehensive Innovation Reform Experiment Zones” and 120 “Double Innovation Demonstration Bases” that were created throughout the country between 2015 and 2017 (Levesque 2019, 6). Such MCF demonstration zones have to be approved by the MIIT and bring together DIEGs with local industry in specified technology fields. The PLA Military Districts are also involved in the promotion and administration of the bases (Levesque and Stokes 2016, 29).

14 of the zones have been created in the Southwestern defence industrial cluster in Chongqing and its surrounding provinces (Ministry of Industry and Information Technology of the PRC 2018). The nationwide promotion of MCF zones has made local governments eager to create their own MCF industrial clusters, but if not approved by the MIIT these clusters do not appear as official MCF demonstration zones (Levesque and Stokes 2016, 29).

Civilian-Military Partnerships

Outreach to civilian universities has expanded as well. Since 1999 COSTIND and later SASTIND has signed agreements to supervise or fund 61 universities that integrate defence research in their education or create defence research laboratories. The majority of these agreements was signed since 2015 and include leading universities such as Tsinghua and Beijing University. Similar agreements have been signed between universities and DIEGs, with the latter supervising students in specific fields. More than 150 Chinese universities have security credentials to participate in classified defence research projects (Joske 2019, 8–9).

5.1.7. Policy Portfolio: Financial Policy

Throughout the 1990s, the Chinese DIB struggled with budgetary constraints that severely obstructed modernization. At the start of the decade, more than 40 percent of factories were outdated for more than 20 years and only 3 percent were considered “advanced”. This was the

result of 10 years of starving in the sector, disincentivising and prohibiting investments into R&D (Cheung 2009a, 95). The government was the only entity financing defence R&D, with the enterprises unable to do so due to the lack of income.

During the 8th Five-Year Defence S&T Plan (1991-1995), all important defence R&D projects overran their planned budgets (Cheung 2009a, 90). This paralleled an overarching problem in the Chinese economy, where only 0.7 percent of the GDP was invested in R&D. The budgetary restraints also limited research in the university sector (Cheung 2009a, 108–110). Indeed, the defence SOEs gained most of their revenue from commercial activities in the civilian market. Until the end of the decade their defence related work had fallen to 20 percent of overall activity (Cheung 2009b, 40).

The transformation of the Machine Building Ministries into SOEs in the early 1990s had little impact on their profitability and efficiency, since the new enterprises were still tightly managed by COSTIND (Cheung 2009a, 39; Cheung 2009b, 40). The high levels of redundancy, owed to the Third Line policy, aggravated the problem, with the defence sector making a continued loss throughout the decade. Defence enterprises were heavily indebted to state-owned banks, since these were obligated to provide loans to SOEs, and at the same time the enterprises were creditors to other SOEs that were unable to pay their bills (Bitzinger and Boutin 2009, 131).

The first major reform step in 1998, the commercialization of the defence sector and restructuring into ten DIEGs, introduced more budgetary independence and responsibility (Bitzinger and Boutin 2009, 133). The restructuring and commercialization of the state-owned defence sector was accompanied by cost-cutting measures and a restructuring of debt. This was complemented by new dedicated funding for defence R&D undertakings (Kirchberger and Mohr 2018, 52). The most crucial change though, was the growth of the Chinese military budget and thus growing domestic acquisitions. In 2002, the DIEGs were able to break even for the first time (Cheung 2009a, 126).

Defence sub-sectors that had been at the forefront of reform efforts, such as the shipbuilding industry, were already able to compete on the international market (Bitzinger and Boutin 2009, 139). A few well managed enterprises were allowed to raise money through bonds and stock market listings of subsidiaries (Cheung 2009b, 41). Throughout the subsequent 18 years, annual revenues continued to grow on average by 20 percent, providing more funding for R&D and innovation (Kirchberger and Mohr 2018, 43). In 1999, an official guideline had set a target for defence enterprises to invest 5 percent of revenue into high-technology R&D (Cheung 2009a,

149). Under the 10th Five-Year Plan (2001-2005), the share of defence-related R&D in the 863-plan was also increased to one third of the overall programme (Cheung 2009a, 153).

In 2004, COSTIND published the “Outline of National Defence Science, Technology, and Industry Policy”, which described the need for expanding investment mechanisms such as private funds and fund raising on stock markets (Cheung 2009a, 122). By 2007, it announced the drafting of new guidelines to allow private and foreign investment in the defence sector (Cheung 2009a, 126).

As displayed in Table 17 and outlined in the respective chapter, between 2007 and 2016 a wave of new regulations established the institutional framework for allowing private sector investments in the defence sector. This created new capital flows for defence enterprises through stock market listings, bond issuances, and joint-ventures, as well as private sector investments into defence R&D and assets (Cheung 2019, 606). Additionally, defence enterprises still receive financial transfers, tax breaks, and low-interest loans (Haley and Haley 2013, 26; Cheung and Hagt 2019, 153).

Official statements by the GAD director indicated that the Chinese DIS had overcome the problem of lacking budgets by 2014, with reform attention shifting to institutional frameworks and mechanisms (Chase et al. 2015, 127). Between 2014 and 2019, Chinese arms exports again nearly doubled (Cheung 2019, 594). At least since 2018, when a first estimate was published, three DIEGs (CSGC, AVIC, NORINCO) are in the ten biggest global defence companies in respect to their revenue. When it comes to financial prowess, they have thus caught-up to major Western defence conglomerates (Kirchberger and Mohr 2018, 54).

The two shipbuilding DIEGs appear to be the only part of the defence sector struggling with profitability, due to a downturn in global demand, despite a major wave of PLA Navy acquisitions throughout the last decade (Kirchberger and Mohr 2018, 55). Although the Chinese defence budget is still the most crucial element for funding defence R&D, its slowing growth has been compensated by the new financing tools (Cheung and Hagt 2019, 153).

Dedicated plans for specific technological fields have been another important tool in the Chinese policy portfolio. Within the assessment period, important plans were the 863 High-Technology Research and Development Plan and the 995 High-Technology Development Plan.

The 995-plan was developed in the wake of the US bombing of the Chinese embassy in 1999, but not officially confirmed until 2015. It is implemented in five-year phases, parallel to the overall five-year planning cycle. It provides funding to selected strategic defence projects to

develop asymmetric capabilities, and aims to boost S&T innovation and push high-end technology breakthroughs. Projects under 995-plan rely on both indigenous and foreign technology transfers facilitated any way possible, including reverse engineering and industrial espionage.

The 863-plan, on the other hand, was an overarching economic development plan for crucial technological areas that also encompassed defence and dual-use undertakings. Initiated in 1986, the plan received increasing importance, scope and funding from 2000 onwards, and ended in 2016. Like the later 995-plan, it was mirrored on the strategic weapon plans implemented during the Maoist era (Cheung 2016 et al., 24–27). Other plans such as the 973 National Basic Research Program and the Torch plan for the commercialization of high-technology inventions, have indirectly benefited the DIS as well (Cheung 2016 et al., 29).

Since 2008, new government finance funds have appeared as new tool to support industrial and technological undertakings. These “guidance funds” integrate public funding and private venture capital, and exist on various governmental levels, both local and national. Their number significantly increased in 2012 and 2013, due to the Strategic Emerging Industry (SEI) initiative, and in 2015 and 2016 due to the new Made in China 2025 plan. By 2018, more than 2000 such funds had been created, designed to mobilize about US \$ 1.89 trillion.

These funds also benefit the defence industry and about 28 percent of them are dedicated to upgrading the infrastructure of SOEs. Additionally, a share of these funds is directly dedicated to MCF-projects (Cheung and Hagt 2020, 18–19). In 2019, it was estimated that 42 guidance funds, identified as MCF funds, exceeded US\$ 73 bn. Eventually, the overall volume is considerably more, as information remains scarce (Fritz and Kennedy 2019).

During the 12th Five-Year Planning period from 2011 to 2016, additional funding programmes for strategic sectors were implemented. These included new loan programmes by state-owned banks and an unknown number of undisclosed finance programmes (Kirchberger and Mohr 2018, 53). Defence-related R&D also profits from the overarching national funds that subsumed the 863-plan. By 2019, these have been consolidated into five major plans: The National Natural Science Fund, the National Major Science and Technology Plan, the National Key R&D Project, the Special Fund for Technology Innovation and the R&D Base, and the Professional Special Plan (Cheung 2019, 604).

5.1.8. Policy Portfolio: Acquisition Policy

Historically the PLA acquisition system has relied on a supply-push system, steered by high-level leadership that coordinated the development of defence products. Thus, during the period of the planning economy, there was little coordination between knowledge producers, manufacturers, and end-users. While this system functioned for strategic programmes, when the leadership gave attention to defence projects, with the reform period much of this leadership support shifted to the rapidly developing civilian economy (Cheung 2009a, 169).

Under the system in place during the early 1990s, military procurement was facilitated through “batch-building” a large number of systems, lacking any quality control or cost-cutting measures (Bitzinger and Boutin 2009, 132). Pricing was defined by a cost-plus model, which included 5 percent profit margins for contractors and was thus an incentive for suppliers to raise costs (Chase et al. 2015, 131). Governmental “local content” mandates forced the PLA to acquire domestic equipment, which often did not meet the required standards, while foreign imports were limited to a few advanced systems (Ahrens 2010, 1).

The closed nature of the defence sector, excluding civilian companies and the sectoral nature of the Ministries of Machine Building and later the DIEGs, established a monopolistic market. Although a contract responsibility system existed since the 1980s, these contracts had limited legal binding and did not outline contractual obligations concerning quality, pricing, or schedules (Chase et al. 2015, 130).

This system was still entrenched in the 1990s, leading to major inefficiencies in the procurement process. The most important shift in defence procurement was the move away from the supply-push towards a demand-pull model, which the effect of organizational and management reforms. The 1998 reforms, establishing the GAD and limiting the control of COSTIND by corporatizing the defence SOEs, enabled the PLA limits itself to the customer role (Bitzinger and Boutin 2009, 133). The previously reoccurring divergence between research results and products on the one hand, and the actual requirements of the armed forces on the other, gave way to a system that brought knowledge-providers, producers and end-users together (Cheung 2009a, 167–168).

Changes to the acquisition management were formalized in the “Four Mechanisms” approach developed in 1998. Three of these mechanisms were designed to solve inherent problems arising from monopolism, conservatism and corruption.

The first mechanism was competition, since the established system of contract responsibility did not punish enterprises for cost overruns. Competition was to be introduced through bidding

calls, increased transparency and punishments for cost overruns. The second mechanism, evaluation, was based on including external consultants for defence projects. Further efforts were better financial audits, the introduction of evaluations for small projects, and the integration of assessments within contractual obligations. The effect of these reforms was nonetheless limited by the continued monopolistic character of the defence industry.

Supervision, the third mechanism, covered the implementation of disciplinary inspection committees, supervision units, and MRO and internal company offices, tasked with fighting corruption. As aforementioned, the lack of coordination between those entities still remained a problem. (Cheung 2009a, 130–132). The “Four Mechanisms” allowed the PLA for the first time to withhold or postpone acquisitions, if expectations were not met. This ability, as well as the option to rely on foreign suppliers, enabled the PLA to realize the demand-pull system (Cheung 2009a, 168).

The implementation of competitive bidding and market pricing systems remained limited to smaller acquisitions, thus throughout the 2000s major acquisitions continued to suffer from the problems of the old procurement policy (Crane et al. 2005, 167). In 2009, a new round of reforms developed by the PLA, the Ministry of Finance, and the National Development and Reform Commission was designed to tackle the insufficient pricing system. Proposals included the introduction of ex-post and ex-ante controls, and multi-pricing methods (Cheung 2019, 615).

Deeper implementation of these reforms took until 2014, when GAD decided on expanding pilot projects of the new models (Chase et al. 2015, 131–132). In 2015, GAD also created the Weapons Acquisition Information Network (WEIAN) to publish procurement notices for private and civilian suppliers, with a further expansion in 2017 (Cheung and Hagt 2019, 159). Reforms have also been implemented by the DIEGs themselves, which have centralized procurement systems in order to streamline contracting to Tier 2 and 3 suppliers (Kirchberger and Mohr 2018, 51).

The limited influence of GAD outside of the PLA Ground Forces was overcome by the 2016 CMC restructuring, establishing the EDD as key entity managing PLA procurement (Cheung 2019, 592–593). Despite the new procurement tools, some observers state that competitive and transparent procurement have not been fully implemented, specifically for large scale and sensitive acquisitions, where sole-source contracts are still employed (Kirchberger and Mohr 2018, 51).

The utilization of new tools has nonetheless been expanded in the years leading-up to 2021, with the majority of defence procurement contracts utilizing more flexible pricing schemes.

Procurement from private enterprises is already more transparent, as the bulk of calls is published on the EDD's WEIAN web portal and facilitated through competitive bidding (Cheung and Hagt 2019, 159–160; Yao 2017a).

5.1.9. Policy Portfolio: Human Resource Policy

In the early 1990s, the Chinese DIB was estimated to comprise of 3.15 to 3.3 million employees (Frankenstein 1999, 192; Cheung 2009a, 112). Throughout the decade, the high levels of redundancy and overcapacity not only diminished the efficiency of the defence sector, but also meant that the Chinese defence industry employed far more personnel than necessary. Even by the late 1990s, the Chinese aircraft industry was estimated to have employed three times the necessary number of workers (Bitzinger and Boutin 2009, 130–131).

The defence R&D sector also continued to suffer from the consequences of the Cultural Revolution. The majority of scientists and researchers was educated in the 1950s and 1960s, and hence the workforce was overaged and awaiting retirement. Only a small minority employed in leading defence R&D institutes was in possession of a graduate degree (Cheung 2009a, 92–94).

As aforementioned, the unprofitability of the sector resulted in a lack of resources for R&D and thus missing potential for researchers and scientists. Additionally, IPR regulations and the lack of a financial incentive system meant that defence personnel could not profit from their findings (Cheung 2009a, 143). The problem was aggravated by more attractive careers in the rapidly developing civilian sector, and the resulting brain drain and recruitment competition (Cheung 2009a, 94).

The major reform restructuring the Chinese DIB and its governmental management system in 1998 also entailed changes to human resource policy. On the one hand, this included the down-sizing of the workforce by one third through retirement, lay-offs, and the reorientation of factories (Bitzinger and Boutin 2009, 133–134). On the other, incentives such as salaries, benefits, and career opportunities were improved. The 1998 concept of the “Four Mechanisms” included encouragement of the workforce, implemented through ideological campaigns, advanced management concepts, and the introduction of market-based incentives and performance-related schemes (Cheung 2009a, 132). Despite the better conditions, the defence sector struggled to compete with better career opportunities in the civilian economy (Cheung 2009a, 94).

To mitigate management problems, the “chief designer model” was replaced by a more centralized leadership structure and “matrix-management” concepts. These improved coordination, responsibility and work division between the players involved in a project. Responsibility was centralized in the hands of a few directors, while project managers were selected on a competitive basis. While previously managers only had administrative measures at their hands, these new managers were able to leverage financial and legal rewards and penalties (Cheung 2009a, 151–152).

The slow change from the old guard to a new generation of researchers, scientists, and managers in the latter half of the 1990s allowed the depoliticization and depersonalization of the R&D system as well. Until the end of the Hu Jintao administration, political interference into research undertakings had all but vanished, and the success of research projects was not tied to the success of individual administrators anymore (Krolikowski 2017, 268).

The DIB’s down-sizing had decreased the number of employees in the defence sector to 2 million in 2000 (Cheung 2009a, 112). Though progressing slower than expected, the workforce was nearly cut in half to 1.67 million employees in 2006 (Bitzinger 2017, 64). Subsequent estimations put the work force employed by the DIEGs at 1 million in 2012 and 2.5 million in the overall sector, including private companies (Grevatt 2013; Lague and Zhu 2012; both quoted by Kirchberger and Mohr 2019, 43). Official figures for the top-nine DIEGs list 1.7 million employees in 2018 (Kirchberger and Mohr 2019, 43).

Talent Recruitment and Education

In anticipation of the recruitment problems, already in the 1980s COSTIND had started to support universities, academies and colleges, and brought 29 educational entities under its mandate (Cheung 2009a, 93). The “211 project” of 1995, the PLA’s complementary “2110 project”, and the 1998 “985 project” provided additional funding to selected universities, including defence universities. COSTIND also implemented separate funding and grooming programmes for the “Seven Sons of Defence”. A dedicated “511 project” was created to recruit outstanding researchers and scientists for defence R&D. This not only improved teaching and research standards, but also rapidly increased the defence universities’ output of graduates. Between 1999 and 2005 the number of graduates increased by 86 percent, of which one-third directly entered defence enterprises (Cheung 2009b, 53; Cheung 2009a, 155–156).

The 211 and 985 projects were followed by the Double First-Class University Plan in 2015, which aims to build 98 Chinese universities into world-class institutions by 2050. The new plan comprises of the same universities as the previous plans, and specifically focuses on promoting

MCF and two-way transfers of technologies between the civilian and military sectors (Joske 2019, 4).

Pursuing the direct recruitment of domestic students, by 2019 the PLA had also established recruitment centres at 2500 universities throughout China. These centres specifically target M.A. and PhD graduates, recruiting them for civilian positions within the army and defence industry that offer the same benefits as to civilian servants. While the defence sector is still in a tough recruitment competition with the civilian sector, the MCF policy is posed to further mitigate it (Kania 2020, 27).

Talent Recruitment Abroad

China has been confronted by brain drain, both due to emigration and the decision of citizens graduating abroad to not return. To tackle the problem, the government has created more than 200 talent-recruitment programmes, primarily targeting ethnic Chinese, since 2008. According to official statements, until 2016 more than 60000 individuals were thus recruited overseas (Joske 2020, 3).

The most important is the Thousand Talents Plan, which includes a 1000 Young-Talent Plan and a Foreign Experts Plan. These plans aim to recruit successful researchers and scientists from around the world. The PLA and subordinate organizations, DIEGs, and defence universities have successfully used the plans to recruit both overseas Chinese and foreigners. Recruitment fields include AI, nuclear physics, and other defence-related technologies (Nouwens and Legarda 2018, 14; Joske 2019, 18–19; Joske 2020, 25–26).

These recruitment programmes are facilitated through the Central Committee's Overseas High-level Talent Recruitment Work Group and more than 600 overseas talent-recruitment stations, which are often run through front groups and organizations. While the brain-drain of Chinese researchers towards the US has also slowed due to increasing restrictions by the latter, the assertiveness of Chinese recruitment allows the conjecture that the final goal is even the creation of a reversed brain-drain (Joske 2020, 7–8).

5.1.10. Summary

Of the three case studies, the Chinese DIS has faced the gravest systemic failures and undergone the most profound reforms. In the early 1990s, the Chinese defence industry displayed numerous inefficiencies and gridlocks. Systemic failures were present in all four categories defined by Woolthuis, Lankhuize, and Gilsing (2005): infrastructure, institutions, interaction, and actor capability.

The defence industry, part of the public bureaucracy, lacked internal and external linkages, and financial resources, and was characterized by high levels of redundancy and inefficiency. Driven by the armed forces' increased demand derived from the "informatized warfare" doctrine, reforms have been extensive. During the subsequent 30 years, all of the framework's elements and policy portfolio have been overhauled.

Organizational overhauls in 1998 and 2016 have established a duopoly of DPA organizations, housed under the CMC and administering the whole industrial life-cycle. Additional organizations for linkage promotion have been established in both the civilian and defence domains. The classical defence industry has been transformed into state-owned defence industrial enterprise groups in 1998 as well, and subsequently received increased independence. These reforms signify the change from the classical innovation theory's pipeline model towards the chain-linked one.

Starting with the moderately successful civilian-military integration (CMI) policy of 2004, the recognition of networks and a further development towards a de-facto national system of innovation approach can be identified. Although efforts towards building the DIEGs into competing entities have failed due to technological path dependencies, the demand for additional high technology and dual-use technology is sourced from civilian and increasingly also private firms. The DIEGs on the other remain stuck by technological path dependency, dividing respective technology fields according to the type of weapon systems.

Breaking down the barriers between the defence and civilian sectors, which accelerated considerably with the military-civilian fusion approach in 2016, shows that the defence sector is already "transitional". This is further underlined by the massive increase of China's domestic security expenditure, estimated to be bigger than its actual defence expenditure (Zenz 2018). Thus, the merger of civilian and defence industries likely also parallels the merger of the defence and security domains outlined in sub-chapter 2.5.3.

The agglomeration of the defence industrial base in South-western and North-eastern provinces, a relic of the Cold War era "Third Line" policy, has decreased and defence subsidiaries have developed a strong presence in high-technology industrial zone in Coastal China. In addition, an extensive cluster policy and the creation of joint research centres at universities have formed strong networks within the DIS and with civilian partners.

The policy portfolio has likewise undergone fundamental changes. Linkage policy: Intra- and inter-sector linkages have been considerably strengthened through the CMI and MCF policies. This includes linkages between civilian and defence organizations, for example through

SASTIND's Strategic Cooperation Framework Agreements. The consolidation of defence enterprises and research institutes in the DIEGs presented an important step for intra-sector linkages. Defence enterprises have established joint ventures and other forms of cooperation with both civilian industries and universities.

Financial policy: In the early 2000s the DIEGs were for the first time able to break even, primarily due to increased defence budgets and respective acquisition projects. Since then, additional finance sources have been opened through investment reforms, new funds such as government guidance funds, and growing exports.

Acquisition policy: Starting from the abandonment of the supply-push model in the late 1990s, acquisition has been adapted in the scope of increased competition, supervision, and evaluation. Competition has been introduced through tenders for the bulk of smaller procurement undertakings. This has entailed new, more flexible pricing schemes, and ex-post and ex-ante controls. Participation of civilian entities has been eased by the introduction of an acquisition web portal.

Human resource policy: Human resources presented one of the most crucial systemic failures of Chinese DIB. During the 1990s, the sector was faced with an oversized and overaged workforce, strong recruitment competition of civilian industries, and the lack of incentives. Through massive funding in universities graduate output increased, and in parallel redundancies were reduced. The 1998 reforms also established new management systems and incentive schemes. Additionally, dedicated recruitment programmes were implemented to alleviate the concerns. The Chinese DIS also profits from the considerable scope governmental recruitment programmes abroad.

The overhaul of the DIS and new policy approaches have likewise affected the institutional framework. While classic defence enterprises are still owned by the state through SASAC, access to private and also foreign investments has been eased. For the latter, their actual management through the recently introduced review process remains to be seen. The bulk of defence contracts, except for strategic and sensitive projects, has been opened. Market entry is thus possible for domestic and in part also foreign entities.

Observers have named IPR management as a systemic failure during the 1990s. Through an overhaul of the defence IPR laws and management, and the creation of a dedicated defence IPR organization, these problems have been alleviated. During the late 2010s, many defence patents have been declassified and the National Defence Intellectual Property Office promotes domestic technology transfers. Although China remains reluctant in acceding to international

arms treaties, the domestic arms export control system has been strengthened and also includes technology transfers. While loopholes persist due to the continued case-by-case utilization of executive orders, stricter controls have aimed to reign in unwanted technology transfers.

China's continuous reform push in the national defence innovation system has entailed considerable liberalizations. In light of the utilized policy portfolio, China's defence innovation policy has transited from classical government approaches to the contemporary generation of innovation policy. Taking into account the macro-economic scope of the MCF policy and its relation to others, such as the Double First-Class University Plan, there is a strong argument that China is already advancing into Boekholt's fourth generation of innovation policy.

5.2. Japan

5.2.1. Policy Portfolio: Overarching Tenets and Planning Instruments

Japan's overarching policy approach for managing its DIS, throughout the Cold War period and until today, is techno-nationalism (Hughes 2011, 451). The approach was shaped by the post-war Yoshida doctrine, which limited the defence budget to 1 percent of GDP, prohibited the export of defence technologies and foreign defence collaboration, and restricted political influence of the defence industry (Kallender and Hughes 2019, 4).

Central elements of the Japanese techno-nationalism are indigenization, diffusion, and the nurturing of technology (Samuels 1994, 319). Indigenous production and the unification of civilian and military sectors are the central tenets of the Kokusanka policy (Hughes 2011, 453). It has enabled the Japanese Self-Defence Forces (SDF) to nearly achieve self-sufficiency in military hardware (Bitzinger 2017, 12).

“Kokusanka” has been the central guidance for the Japanese DPA, and despite its abandonment in 2014, has relevance to this day. According to it, the first and foremost step is the reliance on domestic supply. If it is not available, priority should be given to licenced production. Acquisition of finished military systems abroad is only the last option (Kausal and Markowski 2000, 2-44). The principles of Kokusanka were formalized in the Basic Policy for Development and Production of Defence Equipment of 1970. The policy also incorporated the utilization of civilian industries and the introduction of competition, the latter becoming relevant in the 1990s (Kausal and Markowski 2000, 2-25).

Kokusanka is closely linked to the Japanese defence policy. These are the maintenance of SDF deterrence capability in its unique geographical environment, bargaining power in the context of alliance management, the retention of latent capabilities and self-sufficiency, as well as the utilization of dual-use technologies (Hughes 2011, 454). In this context the Japanese government has relied on dedicated “Kokusanka projects” to sustain the Japanese DIB (Hughes 2011, 458).

The integrated nature of its civilian and defence industries has provided Japan a leading edge, while other nations strive for integrating their separated civilian and defence sectors. Despite that, the Japanese model has encountered its own problems in maintaining a potent domestic DIB since at least the 1990s (Hughes 2011, 452). The problems were declining defence budgets and Self Defence Forces' (SDF) demand, an outdated procurement policy, and the self-imposed limitations to international collaboration (Hughes 2010, 1).

Since the late 1990s, governmental reports have thus acknowledged a crisis of the Japanese DIB and outlined crucial reforms. Otherwise, the potential loss of technological leadership and of essential indigenous capabilities was expected (Hughes 2011, 472–476). The need for reform became more pressing with two corruption scandals in 2007, which displayed harmful collusion between defence organizations and the industry (Hughes 2008, 71). Since the 2010 National Defence Programme Guideline's (NDPG) target of achieving a “dynamic defence force” and the begin of the Abe administration in 2012, reforms have picked-up speed in the context of Japan's slow military “normalization” (Sakaki and Maslow 2020, 6). The intensifying reform approach was formalized in Japan's first version of a National Security Strategy in 2013 (JMoD 2014a, 1).

The 2014 Strategy on Defence Production and Technological Bases officially substituted the 1970 Basic Policy for Development and Production of Defence Equipment, also called Kokusanka. The new policy outlined three overarching goals for the Japanese DIB. These are: “(1) Ensure sovereignty of security, (2) contribute to latently enhanced deterrence and maintain and enhance bargaining power, and eventually (3) contribute to advance domestic industry driven by highly sophisticated technology” (JMoD 2014a, 5).

Subsequent efforts targeted both the organizational structure of the DPA, acquisition policy, the links between the defence and educational sectors, international collaboration and a liberalization of arms export regulations. These reforms are not only driven by domestic industrial problems, but also by rapidly rising demands on the SDF, due to the deterioration of the security environment. This is also displayed by the shortened periods between revisions to the NDPGs after 2004.

Japanese reform undertakings are in a field of tension between constitutional restraints and anti-militaristic sentiment, and the growing capability needs for national defence (Hughes 2019a, 400). They have thus developed in an evolutionary, gradual nature rather than in one push (Takahashi 2012, 3). In step, policy making has become increasingly top-down, in contrast to the previous strong influence of the defence industry and lower organizations (Sakaki and Maslow 2020, 14). The efforts to strengthen international R&D collaboration since 2017 signify the departure from the Kokusanka policy (Hughes 2019a, 431).

The National Defence Basic Policy is a long-standing baseline for Japanese defence activities, first promulgated in 1957. It outlined Japan's commitment to the United Nations, international cooperation, the alliance with the United States, and the development of defence capabilities necessary for safeguarding national security. Until 2005, only three versions of the NDPG have

been published, in 1976, 1995, and 2004. In 2007, the Japanese Defence Agency became a fully-fledged ministry – the Japanese Ministry of Defence. After that, the NDPG was adapted more regularly, with new versions published in 2010, 2013 and 2016.

Not only did the NDPGs become more extensive and detailed between 1995 and 2019, but the focus and prominence of defence industrial policy and related areas has likewise increased. In fact, the 1995 NDPG was the first to specifically mention the defence industry and respective reforms (Kausal and Markowski 2000, 2-21).

Table 18 – Goals of the National Defence Programme Guidelines 1976 – 2020 (JMoD 2020a, 215)

	Doctrine	Basic Ides
NDPG 1976	Basic Defence Capability	minimum-necessary force
NDPG 1995		major disasters / building a stable security environment
NDPG 2004		independence and international peace cooperation
NDPG 2010	Dynamic Defence Force	deterrence and proactive activities
NDPG 2013	Dynamic Joint Defence Force	achieving maritime supremacy and air superiority
NDPG 2018	Multi-domain Defence Force	cross-domain operations in land, sea, air and new dimension (space, cyber, electromagnetic)

Planning Instruments

Japanese defence industrial policy is guided by three overarching documents: The National Defence Basic Policy (NDBP), the National Defence Programme Guidelines (NDPG), and the Mid-Term Defence Programme (MTDP). As outlined above, the NDPG defines the overall defence policy, armed forces posture, and doctrinal focus. The MTDP on the other hand is a five-year plan that outlines SDF development and major equipment acquisitions. It sets the guidelines for the annual budget (JMoD 2020b, 3).

In 2006 the Japanese Ministry of Defence (JMoD) has also for the first time published a medium-to-long term Defence Technology Outlook (DTO), determining the requirement for future technologies and including a 20-year outlook on S&T efforts. In 2016 the DTO was reviewed and a new version published, now managed by Acquisition, Technology & Logistics Agency (ATLA) (ATLA 2016, 12–13). In addition, an overarching Defence Technology

Strategy (DTS) was also for the first time published by JMoD in 2016. It outlines the broad policy strokes for defence S&T (JMoD 2016b, 3–5). JMoD also publishes the “Technology R&D Visions”, which define R&D fundamentals and technological obstacles, including R&D roadmaps for achieving future capabilities. These visions are shared with the defence industry as well. Together the DTS, DTO and R&D Vision form the policy framework for ATLA’s undertakings. ATLA is Japan’s centralized DPA since 2015.

Table 19 – Japan’s DIS Planning Instruments (JMoD 2016b, 4–5; JMoD 2021, 209–210; 440–442)

Name	Content	Timeframe
Defence Technology Strategy (DTS)	outlines general technological policy objectives and the basic approach for their implementation	5 years
Medium Term Defence Programme (MTDP)	outlines acquisition projects and maximum budgets yearly budgets are determined by the MTDP	5 years
Medium- to Long-Term Defence Technology Outlook (DTO)	links DTS with MTDP outlines the mid- to long-term S&T efforts and R&D undertakings	5 years
Technology R&D Visions	outlines fundamental R&D policy and R&D undertakings on essential technologies	no clear cycle, published 2010, 2016, 2019
Basic Policy for Development and Production of Defence Equipment of 1970	established the Kokusanka doctrine	-
2014 Strategy on Defence Production and Technological Bases	outlines policy measures to strengthen the DIB	-
5th Science and Technology Basic Plan (2016-2020) 6th Science and Technology Basic Plan (2021-2025)	determines S&T policy direction	5 years
Comprehensive Strategy on Science, Technology and Innovation	outlines S&T issues and initiatives; determines fiscal priorities for subsequent year	annually

The JDA and JMoD have also utilized more enduring strategies aiming to transform the DIB. These are the aforementioned Basic Policy for Development and Production of Defence Equipment of 1970 and the succeeding 2014 Strategy on Defence Production and Technological Bases (JMoD 2016b, 4). Showcasing the increased attention to the defence industrial base by policy makers, the 5th Science and Technology Basic Plan and the Comprehensive Strategy on

Science, Technology and Innovation 2016 for the first time included topics and projects for national security and R&D (JMoD 2016b, 4).

5.2.2. Organizations

Until 2007, the Japanese Defence Agency (JDA) was the governmental body administrating the Japanese Self Defence Forces (SDF). The JDA was part of the Office of the Prime Minister, headed by a Director General with the rank of a Minister of State. Despite that, the JDA was not a cabinet level department. Commanding the three service branches and the Joint Staff Council of the SDF, the JDA had internal bureaus managing defence acquisition and R&D (Kausal and Markowski 2000, 2-14).

The Equipment, Finance, and Defence Policy Bureaus were the main players in the defence acquisition process. The Equipment Bureau handled acquisitions, while the Finance and Defence Policy Bureaus determined respective budgets and policy guidelines. Defence R&D, but also testing and evaluation, were solely managed by the Technical Research and Development Institute (TRDI). The TRDI handled R&D contracts with the defence industry, conducted internal research projects, and identified defence-potentials in civilian technologies. For this purpose, it had four programme departments, five research centres and five test centres under its oversight (Kausal and Markowski 2000, 2-17).

The JDA had limited independence, as the heads of the Equipment, Finance, and Defence Policy Bureaus were nominated by other ministries (Kausal and Markowski 2000, 2-15). For example, the Ministry of International Trade and Industry (MITI) appointed the JDA Equipment Bureau head from its own Heavy Industry, Aircraft or Ordnance departments (Samuels 1994, 323).

Acquisition plans and strategies were developed by a separate Equipment Review Council, consisting of the heads of the JDA's internal bureaus. Major acquisitions had to be approved by the Ministry of Finance, the Security Council, the Cabinet and the Diet (Kausal and Markowski 2000, 2-31). The JDA also had a separate Central Procurement Office (CPO) that acted as contracting body for the acquisition of finished military systems, and the Defence Facilities Administration Agency that managed acquisition, construction, and maintenance of the SDF's properties (Kausal and Markowski 2000, 2-19). The SDF service branches also had their own departments for the drafting requirements for and testing new equipment (Kausal and Markowski 2000, 2-20).

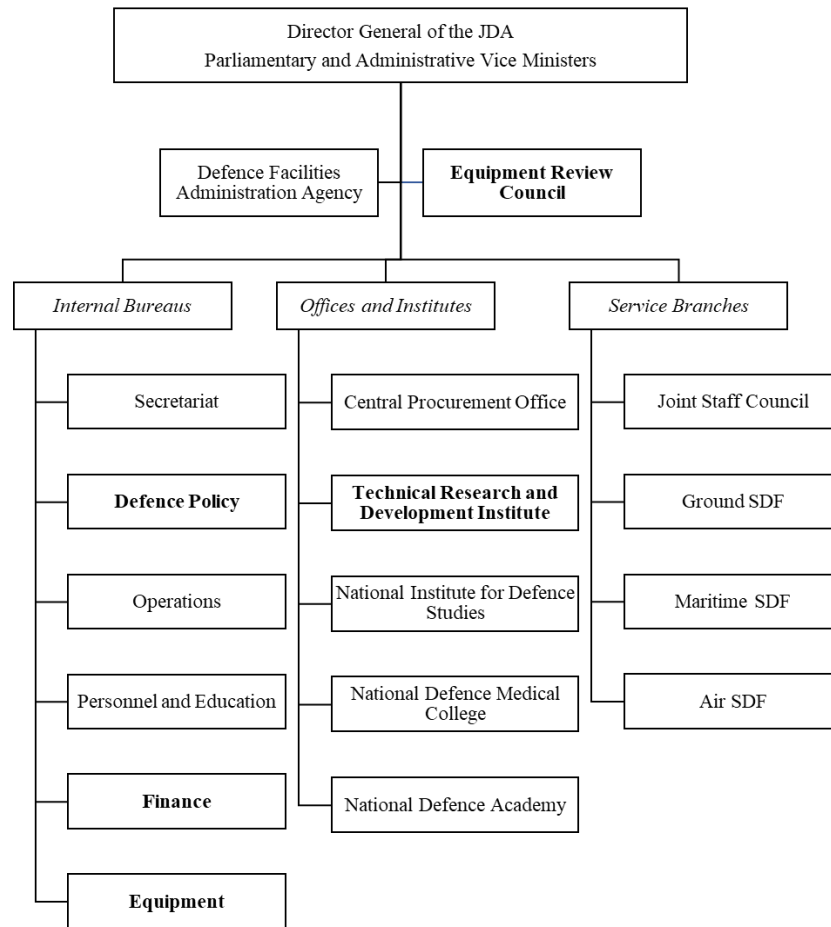


Figure 5 – Japanese Defence Agency Organigram in 2000 (Kausal and Markowski 2000, 2-25)

In 2001, a first step towards consolidation was undertaken through the merger of the Bureaus of Equipment and Finance into the Bureau of Equipment and Finance, and the creation of a Central Contract Office (JMoD 2007, 618). The bureaus were merged to increase the efficiency of procurement and enable a life-cycle approach for procurement projects. The Central Contract Office on the other hand was created to centralize contract and cost management in one body. By 2006, the office had become the Equipment Procurement Office. In 2007, the Japanese Defence Agency was reformed and elevated, becoming the Japanese Ministry of Defence (JMoD). The Defence Facilities Administrative Agency was dissolved and merged with the new JMoD (JMoD 2007, 193–199). Through this merger, all contracting was centralized in the Equipment Procurement and Construction Office (JMoD 2008, 325–326).

The most crucial reform of the Japanese DPA was implemented in 2015, when all functions related to defence procurement and R&D were centralized in the new Acquisition, Technology and Logistics Agency (ATLA). This included the merger of the Bureau of Equipment and

Finance, the Technical Research and Development Institute, the Equipment Procurement and Construction Office, and respective functions of the joint staff office and the service branches. ATLA was founded as an extra-ministerial body, therefore being formed outside of the JMoD as a separate body. The agency was designed to promote four objectives: Implementing a unified project management for the whole live-cycle of equipment, efficient identification of defence procurement needs, active engagement in the internationalization of equipment, boosting advanced technology research, and conducting further procurement reforms (JMoD 2015, 220). Functions related to procurement of the service branches, such as testing, were consolidated in the Logistics Planning Department, while related policy planning was delegated to the newly formed Bureau of Defence Build-up Planning. Eight Regional Defence Bureaus manage relations on the local level, in respect to equipment procurement (JMoD 2016a, 280–282).

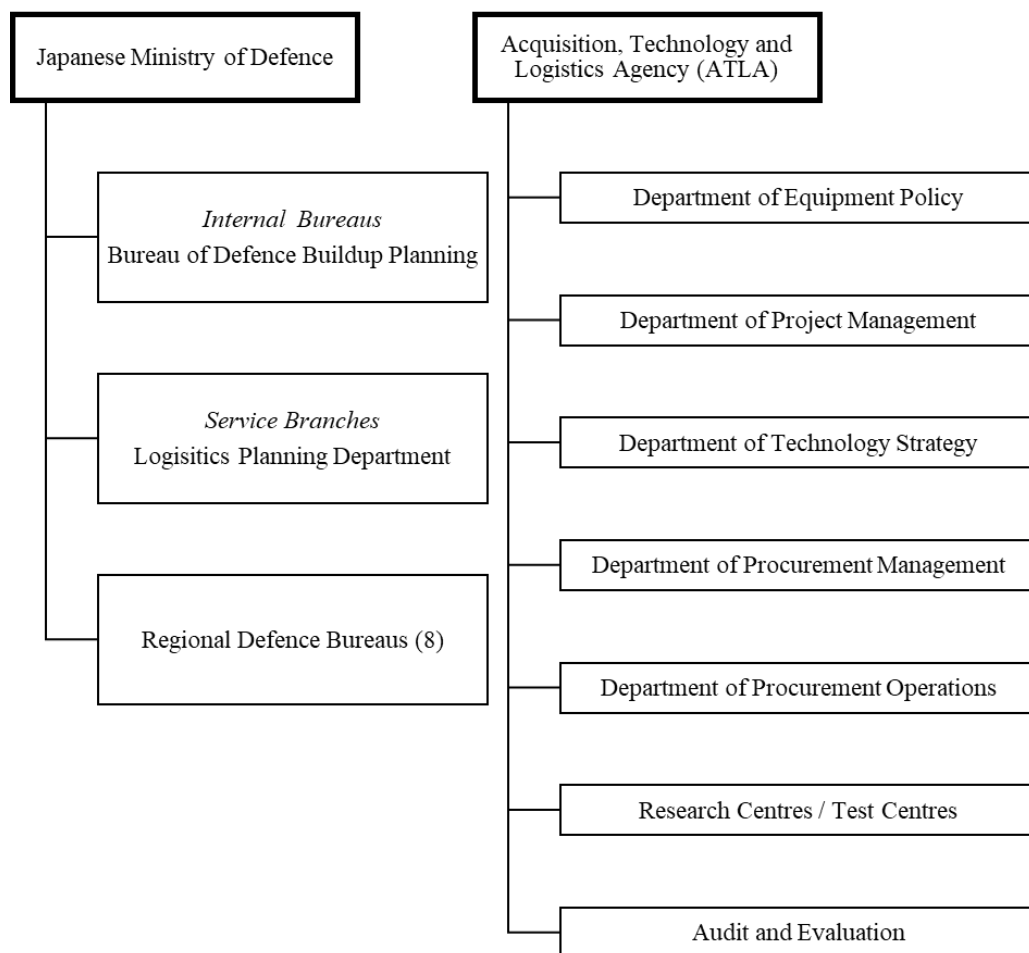


Figure 6 – Japanese Defence Procurement Agency Organigram in 2016

Civilian Organizations

Due to the unified nature of Japan's economy, civilian ministries have played an important part in managing the defence sector. The Ministry of International Trade and Industry (MITI) was the most important authority in this regard, overseeing industrial policy and the public funding of R&D for major parts of the Japanese industry. Thus, it was also overseeing the major conglomerates forming the defence industrial base. MITI had the authority to identify and promote key technology sectors and nurture them through preferential policies and funding (Alexander 1993, 25).

Together with the JDA Equipment Bureau and the overhead bodies for the defence industry, the Keidanren and the Japan Association of Defence Industry, MITI managed the competition for defence contracts. As outlined above, MITI had its own divisions dealing with heavy industries, aerospace, and ordnance production, and appointed the JDA Equipment Bureau's head (Samuels 1994, 323). MITI also controlled access to the defence market and was hence the central player nurturing the monopolies and oligopolies in the DIB (Alexander 1993, 19–20; Hughes 2019a, 424). In the framework of the 2001 governmental reform, MITI merged with the Economic Planning Agency and other governmental bodies to form the Ministry of Economy, Trade and Industry (METI). METI continues its role as central agency for industrial policy, promoting the utilization of dual-use technology and domestic technology transfers (Hughes 2011, 454).

Another influential organization in the Japanese DIS is the Ministry of Finance (MOF). During the 1990s, the ministry appointed the JDA Bureau of Finance's head. The MOF also prepares the guidelines for the defence budget and has exerted its influence to promote cost-reduction and -effectiveness in SDF procurement (Kausal and Markwoski 2000, 2-17–2-22). The Ministry of Foreign Affairs (MOFA) has also taken a role in defence industrial policy, due to its promotion of collaboration in the frame of the US-Japan security alliance and its facilitation of joint-development undertakings with other international partners (Hughes 2019a, 401).

Beyond the central actors in defence industrial policy, the Ministry of Transportation has some influence, due to its supervision of the shipbuilding sector (Alexander 1993, 25). In 2001, it was merged with other ministries to form the Ministry of Land, Infrastructure, Transport and Tourism. The Japan Information Centre of Science and Technology (JICST) and the Japan Research Development Corporation (JRDC) were involved in funding dual-use R&D projects (Samuels 1991, 55–56). In 1996, the two organizations were merged into the Japan Science and

Technology Corporation, which was reorganized into the Japan Science and Technology Agency (JST) in 2003. JST is the central organization funding and managing R&D (JST 2020).

Japan's Keidanren

A unique body, which also presents an organization within the Japanese DIS, is the Japanese business organization Keidanren. It represents the defence industrial enterprises. Although representing actors, the Keidanren Defence Production Committee had a significant impact on policy making and managing defence procurement. Since many of its members are long-term financial supporters of the Liberal Democratic Party (LDP), they hold considerable sway for influencing policy making (Alexander 1993, 25). Keidanren was closely involved in defence procurement policy, managing competition in collaboration with the JDA and MITI (Samuels 1994, 323; Kausal and Markowski 2000, 2-45). Although Keidanren's direct involvement in the DPA seems to have ended with the 2007 JDA reforms, the association has clout for promoting reforms. For example, it influenced the adaption of the institutional framework regulating arms exports and international cooperation (Sakaki and Maslow 2020, 5).

5.2.3. Actors

Due to Japan's policy of nurturing and sustaining defence industrial enterprises, while promoting monopolies and oligopolies, the Japanese DIB has remained mostly stable since 1991. In fact, most major civilian manufacturing companies are participating in the defence industry (McIntosh 2012, 52). The Japanese defence market is separated in monopolies or sometimes duopolies in specific product fields (Bitzinger 2017, 12).

The stability of the defence actor landscape was first and foremost the result of the Kokusanka Policy, which limited competition and nurtured the defence divisions of these companies. The management of acquisition policy has thus created a path dependency for defence contractors. The negative impact on enterprise reputation in pacifist Japan also disincentivized enterprises to enter the market, while motivating established ones to shroud their involvement (Hughes 2019a, 423–424).

None of Japan's major defence companies is state-owned, but they have profited from close relationships with the JDA/JMoD and the ruling Liberal Democratic Party (Alexander 1993, 25). Mitsubishi Heavy Industries (MHI) continues to be the leading Japanese defence actor, having lost its top spot only once in the last three decades. The top 20 defence companies in general receive over 75 percent of defence contracts, with roughly 25 percent going to MHI alone (Hughes 2019a, 408).

Table 20 – Japan's Top-10 Defence Enterprises in 1990, 2000, 2016

1990*	Share of contracts	2000**	Share of contracts	2016**	Share of contracts
Mitsubishi Heavy Industries (MHI)	28	MHI	24.5	MHI	24.6
Kawasaki Heavy Industries (KHI)	9.3	MELCO	9.6	KHI	5.4
Mitsubishi Electric (MELCO)	6.4	KHI	7.8	NEC	4.9
Ishikawajima-Harima Heavy Industries (IHI)	5.0	IHI	4.3	Fujitsu	4.3
Toshiba	3.8	NEC	3.7	MELCO	4.2
NEC	3.5	Toshiba	3.4	Japan Marine United	2.2
Japan Steel Works	2.2	Zosen	2.9	IHI	1.9
Komatsu	1.4	Komatsu	2.6	Toshiba	2.3
Fuji Heavy Industries (FHI)	1.4	Shinmaywa Industries	2.2	Komatsu	1.7
Hitachi	1.3	NEC Business Machines	2.1	FHI	1.7

* Samuels 1991, 57

** Hughes 2019a, 408–421

Throughout the assessment period, defence accounted for less than 1 percent of Japanese industrial output (Hughes 2019a, 404). This ratio applies for most sectors, with only aerospace and shipbuilding being exceptions. While defence projects had accounted for roughly 75 percent of aerospace production in the late 1990s, the share had fallen to less than 30 percent in 2015. Shipbuilding moved between 5 and 10 percent during the same period (Hughes 2019a, 407). Even for major defence enterprises, defence production only accounts for a small share of their sales. At the beginning of the 1990s, on average less than 20% of overall sales of the top-10 defence conglomerates were connected to defence. None exceeded 30% (Alexander 1993, 18). By 2018 the share had dramatically fallen, with only MHI having 10 percent of its sales in defence production (Hughes 2019a, 408).

Beyond the layer of system integrators, a vast number of SMEs is involved in defence projects. In contrast to the limited reliance of major companies on defence contracts, many of the SMEs are specialized suppliers that revenue relies between 50 and 90 percent on defence projects (Hughes 2019a, 408). Around 2000, the Japanese DIB was estimated to consist of over 1300 companies in total (Kausal and Markowski 2000, 2-43). Keidanren's proposal for the new

NDPG in 2010 lists about 1200 companies related to aerospace-, 2500 related to destroyer-, and 1300 related to vehicle-projects for defence (Nippon Keidanren 2010). In the shipbuilding sector, more than 80 percent of work on defence projects is actually done by SMEs (Hughes 2011, 456). The small number of major defence enterprises receiving SDF contracts are thus complemented by a vast number of tier 1 and tier 2 suppliers, which are often more invested in defence than the major defence conglomerates.

Despite the policy of nurturing defence enterprises, the fall in defence budgets and acquisition took its toll on the Japanese defence industry during the 1990s. While the JDA envisioned a consolidation of the DIB, the lacking reliance on defence revenues and integrated civilian-military production meant that rationalization was of little incentive to enterprises. Some companies thus stopped defence production altogether, such as Nissan (Hughes 2019a, 430).

Showcasing the exit of SMEs, the number of subcontractors involved in the Type 90 main battle tank shrank from 1300 to 230 firms. Some firms went bankrupt, while others reoriented towards solely civilian production (Hughes 2011, 473). Consolidation occurred in the shipbuilding sector, where in 1995 IHI and Sumitomo Heavy Industries founded IHI Marine United, and NKK and Hitachi created Universal Shipbuilding. Both these enterprises formed Japan Marine United in 2013 (Hughes 2019a, 430).

R&D Actors

Due to the integrated nature of Japan's civilian and defence sector, and enterprise focus on dual-use technologies, there are only a few dedicated defence research institutes. These are all internal institutes subordinate to JMoD. Beyond them, R&D is undertaken, with a dual-use focus, by internal research institutes of major companies and SMEs. Until the formation of ATLA in 2015, the TRDI supervised Japan's five defence research centres (Kausal and Markowski 2000, 2-19). Since then, the research centres are subordinate to ATLA (ATLA 2020). Outside of ATLA, the National Defence Academy of Japan also has a Graduate School of Science and Engineering (JMoD 2020a, 208).

Table 21 – ATLA research centres (ATLA 2020)

ATLA research centre	R&D field
Air Systems Research Centre	aircraft, components, missiles
Ground Systems Research Centre	combat vehicles, engineering equipment, firearms, ammunition, ballistic and blast resistant structures
Naval Systems Research Centre	naval vessels, underwater weapons, underwater equipment, mine sweeping
Electronic Systems Research Centre	information, communication, radar and infrared technology
Advanced Defence Technology Centre	modelling and simulation, human engineering technology, NBC defence, robots, future weapons and equipment

5.2.4. Institutions

Ownership and Investment Regulations

The 1948 Foreign Exchange and Foreign Trade Control Law and the superseding 1998 Foreign Exchange and Foreign Trade Act give the Ministry of Finance and MITI/METI the authority to regulate foreign investments into the Japanese industry. The law has been utilized to prohibit foreign investments into the Japanese defence industry (Hughes 2011, 466–467). In May 2020, the Japanese government formally restricted foreign investments in 12 core strategic sectors, including defence, and established a screening mechanism. Under the new rules, the government has to approve investments that exceed 1 percent of an enterprise. Previously the limit had been set at 10 percent (Takami 2020). In this context, the Ministry of Finance published a list classifying 3823 enterprises into three categories. Category 1, comprising of companies in core sectors, lists 1663 enterprises that fall under the new rules. These include all major defence contractors (JMoF 2020).

Defence Market Entry Regulations

MITI, subsequently METI, is the main player controlling access to the defence market. The ministry was delegated the authority to supervise the defence industry by the 1952 Ordnance Manufacturing and 1953 Aircraft Manufacturing Industry Acts. They authorised MITI to administrate access to the arms production sector, implement a licence system, and thus control the extent of defence undertakings within the economy (Kausal and Markowski 2000, 2-45; METI 2018).

MITI has utilized this authority to also regulate access to different technology fields within the defence economy, in order to inhibit unwanted competition. This strict control safeguards the

profit margins of defence enterprises, but its deliberate maintenance of monopolies and oligopolies also undermines supply security. When the Japan Aviation Electronics Industry was banned from defence procurement due to illegal exports, the SDF lacked a secondary source for the supplied material (Alexander 1993, 19–20).

Where contracts were handed to foreign enterprises, indirect offsets through a licencing system were utilized to strengthen the domestic industry. When the US government became more reluctant to allow such unidirectional technology flows, Japan moved towards enabling collaboration. Direct offsets are forbidden by Japan’s fiscal and account laws, and there has been no attempt to reform them (Takahashi 2008, 114–115).

Intellectual Property Rights

So far, Japan does not have a dedicated defence patent law. In general, IPR are managed through four overarching laws: The Patent, Utility Model, Design, and Trademark Acts. In the defence sector, since 1958 the Directive on Protection of Special Defence Secrets and the Directive on Confidentiality defined the provisions for confidentiality and information security in the defence sector. Following these directives, enterprises had to utilize separate IPR management systems in their defence departments. The 1964 Directive on Personnel Inventions outlined that the JDA inherits the IPR created by SDF personnel. According to the 1948 National Government Asset Act, IPR generated through contracts was owned by the government as a whole (Harasaki 2018, 72–73).

Following concerns on the negative impact on industry performance in R&D, in 1999 the Act on Special Measures Concerning the Revitalization of Industry was implemented. For the defence sector, the JDA adapted its own “Directive on the Handling of Rights to Patents” on research and experimental contracts in 2002. Following these adaptations, IPR created through research contracts stays with the contracting entity. Research results created by SDF personnel remain government assets, while those created through joint undertakings are jointly owned. Results created in production and service contracts, products of computer programming, and technical materials, such as blueprints, are still transferred to the public sector. As enterprises retain the copyright, the government needs their consent for the reproduction of such products (Harasaki 2018, 74–78)

While these adaptations increase incentives for enterprises to engage in defence R&D, they have created some ambiguity on the actual ownership of results. This has hindered international cooperation efforts in the defence sector. The Ministry of Defence also has not yet adopted METI’s stipulations on patent pools included in the “Guidelines for Intellectual Property

Management in Government-commissioned Research and Development”, which would ease the utilization of research results (Harasaki 2018, 78–79). Furthermore, concerns have arisen on retaining critical IPR and preventing unwanted technological transfers. ATLA’s 2016 Defence Technology Strategy thus outlines the creation of a system for intellectual property control and the evaluation of sensitive dual-use technologies in collaboration with METI. The new system will also incorporate a “open and closed strategy”, according to which IPR will be divided in disclosed and concealed depending on their sensitivity (JMoD 2016b, 14–15).

Arms and Technology Export Control

Japan has a very strict arms export control law, which for major parts of the Cold War had forbidden arms exports and technology transfers altogether. The 1948 Foreign Exchange and Foreign Trade Control Law and the 1949 Export Trade Control Law had given MITI the authority to regulate exports. The 1949 Export Trade Control Order on the other hand specified regulated products (Kausal and Markowski 2000, 2-41). Since 1980, the Foreign Exchange Order also specifies restricted technologies. In 1998, the Foreign Exchange and Foreign Trade Act superseded the 1948 law, taking into account changes in the foreign exchange business (CISTEC 2015, 3–4).

While Japan had exported arms to the US and Southeast Asian nations in the 1950s and 1960s, the “Three Principles of Arms Export” restrained them in 1967. After further discussions in the Diet, arms exports were banned in general in 1976 (Takahashi 2008, 103–104). Nonetheless Japan continued to export dual-use technologies utilizable for defence to China, Southeast Asia and Africa (Hughes 2008, 72). Since 1983, Japan and the US agreed on the transfer of defence technologies, although these had to be permitted on a case-by-case basis by the Japanese government.

Further adaptations were implemented in context of the alliance in 1996, when Japan adapted its arms export policy in order to enable acquisition and cross-servicing. In 1997 and 1998 arms export for SDF humanitarian mine clearing and evacuation missions was permitted (Kausal and Markowski 2000, 2-41). The SDF, Keidanren, and other stakeholders of the Japan-US alliance had started arguing for a more overarching easing of export restrictions since the late 1990s. This was driven by concerns that the restrictions obstructed joint R&D with the US industry and prohibited defence companies from gaining revenue in the international market (Sakaki and Maslow 2020, 1–7).

The legal adaptations allowing the co-development of ballistic missile defence with the US in 2004 were a first step in that regard (Hughes 2008, 74). In 2011, a joint statement of the US-

Japan Defence Consultative Committee for the first time defined the conditions for exporting these missiles (Takahashi 2012, 2). In 2014, the Abe administration proclaimed the “Three Principles on Transfer of Equipment and Technology”, replacing the 1976 ban. The principles basically reset policy back to the 1967 version, allowing joint R&D and exports. In the process, ATLA received the mission to promote Japanese defence exports abroad. METI controls both arms export and arms related technologies through a licence system, with an exception for technology transfers to the United States (Sakaki and Maslow 2020, 1–7).

Table 22 – Japanese arms export policies (Hadlow and Pyror 2018, 2)

Year	Policy Guidelines	Restrictions / Exceptions
1967	Three Principles on Arms Export and Their Related Policy Guidelines	Prohibited arms export to: Communist countries countries under UN arms embargoes countries (likely) involved in international conflicts
1976	Ban on arms exports	Overarching ban to all countries
1980	Ban on technology exports	
2014	Three Principles on Defence Equipment Transfers	Permitting arms exports to contribute to global peace or to improve Japanese security

In line with Japan’s strict policies on arms exports and defence technology transfers, the country has an original signatory to most important international arms trade treaties.

Table 23 – International Arms Export Regimes signed by Japan

Year	Agreement	Target Area
1974	Nuclear Suppliers Group (original signatory)	nuclear proliferation
1985	Australia Group	biological and chemical weapons
1987	Missile Technology Control Regime (original signatory)	missile and missile technology proliferation
1996	Wassenaar Arrangement (original signatory)	conventional arms, dual-use goods and technologies
2014	Arms Trade Treaty (original signatory)	conventional arms

5.2.5. Policy Portfolio: Linkage Policy

The Kokusanka policy and Japan’s deliberate restraint of separating civilian and defence industries was originally designed to enable technology spin-offs that would benefit civilian enterprises. With the general shift towards civilian technological leadership, focus shifted to

spin-on and dual-use concepts (Alexander 1993, v). Since major defence integrators were, in regard of their revenue, civilian companies, linkage policy received little attention in Japan. Although the Directives on Protection of Special Defence Secrets and on Confidentiality mandated some separation of defence from civilian work, enterprises are in general able to simultaneously utilize personnel, knowledge, technology and production facilities for defence and civilian projects (Alexander 1993, 27–28). The exchange of knowledge, technology and experiences between the civilian and defence units within a company is encouraged by the JDA/ATLA (Cheung 2009a, 231).

The close links established within the Japanese economy ease the flow of knowledge within and between defence enterprises, as well as between industrial regions. The JDA's micro-management of defence procurement furthermore established work divisions and linkages between respective suppliers (Alexander 1993, 20–21). This stability of industrial regions and inter-firm relationships has created enduring links that are also maintained during times of re-orientation and recession (Samuels 1994, 321–322). While in the Japanese economy of the early 1990s 80 percent of research collaboration occurred vertically within the supply-chain, 20 percent was conducted horizontally between competitors. This collaboration was even stronger in the defence economy, although no official numbers are available (Samuels 1994, 325–326).

Historically, the SDF and defence enterprises lacked links to universities, since the latter were unwilling to participate in the defence economy. Only with the creation of ATLA did the Abe government establish funding mechanisms for defence-related research in universities. ATLA has been tasked with facilitating technology spin-offs from civilian SMEs and universities. In 2015 the “Innovative Science & Technology Initiative for Security” programme was launched to fund civilian R&D with defence relevance and boost university involvement (JMoD 2020, 428).

While the number of applications grew from 44 in 2016 to 104 in 2017, it dropped again to 73 in 2018. This reluctance was in part the result of a public backlash, with the Science Council taking a stand against defence-related research in universities and calling for screening systems to prevent them. Likewise, while Keidanren welcomed the Impulsing Paradigm Change through Disruptive Technologies Programme (ImPACT) 2013-2018, voices from the science community criticized its potential funding of defence-related technologies (Sakaki and Maslow 2020, 11). Despite the opposition, the current Defence White Paper 2020 nonetheless emphasizes the collaboration and personnel exchange of ATLA with domestic research institutions and universities (JMoD 2020a, 427–428).

Foreign Linkages and Collaboration

Since the 1976 ban on arms exports and technology transfers, the SDF and Japanese DIB were unable to cooperate with foreign partners. When the SDF had to import defence systems from the United States though, both the industry and the administration were keen to produce the systems under licence. Following the Kokusanka policy, the aim was to absorb the lacking technology and strengthen future autonomy (Samuels 1994, 327).

The procurement in the framework of Foreign Military Sales (FMS) was not only seen as a fast, cheap, and low-risk path to required equipment, but also an opportunity to absorb such technology. Whenever possible, licenced production was thus preferred, even though it raised costs (Hughes 2011, 454). In parallel to the defence industry absorbing advanced technologies, the share of domestic production in licenced production nonetheless decreased. The US government became more reluctant to permit one-directional technological outflow and increased fees, concerned with the lacking reciprocity of the Japanese side. The fear of Japan's DIB falling under a "Galapagos effect", therefore dropping behind in technological leadership due to isolation, increased pressures to enable foreign technology transfers (Hughes 2019a, 429).

During the 1990s, a gradual switch from licencing to co-development was thus implemented (Hughes 2011, 467). This was eased by previous steps exploring potential collaboration. In 1980 the US-Japanese Systems and Technology Forum, headed by the JDA Equipment Bureau and his US pendant, was established to explore collaboration (Kausal and Marowski 2000, 2-40–2-41). Subsequently, in 1983 the Exchange of Technology Agreement Between Japan and the United States was signed, enabling exceptions for technology transfers to the US and allowing Japanese enterprises to sub-contract (Hughes 2019a, 399).

These exceptions from the overall ban allowed Japan to sign 21 co-development projects with the US until the policy change of 2014 (Sakaki and Maslow 2020, 4). Co-development enabled a new path to absorb advanced technology, as possibilities for licencing dried-up. Japanese policymakers are nonetheless concerned of a co-option of Japanese defence actors by the US industry, which could endanger Japanese autarky (Hughes 2011, 467–468).

The 2004 agreement on co-development of ballistic missile defence was a critical breach of the ban that enabled the JMoD to justify collaboration with foreign partners in non-contentious fields, such as terrorism and privacy (Hughes 2011, 471–472). It was driven as much by Kokusanka concerns, as by the North Korean and Chinese missile programmes (Takahashi 2008, 111–112). In 2011, the Japanese government issued the "Statement on Guidelines for

Overseas Transfer of Equipment”, which paved the road for future collaboration with other nations than the US (Hughes 2019c, 36).

The JMoD had already searched for other loopholes in the ban and was able to send researchers to both Sweden and France. In 2013, Japan signed its first international agreement on defence technology cooperation, aside from the US, with the United Kingdom. The policy shift was formalized in 2014 with the new Three Principles on Defence Equipment Transfers, which effectively ended the previous general ban on collaboration (Hughes 2011, 472).

As displayed in Table 24, since then a number of agreements were signed with partners in Europe and Asia. The government is exploring further potentials to collaborate in the development of a next-generation fighter aircraft and submarine technologies with the UK and Australia. ATLA has organized defence business forums in European partner countries, Australia and India, and is actively promoting Japanese defence products at international arms expos (JMoD 2020, 442–444; ATLA 2021).

Table 24 –Japan’s Agreements on International Defence Industry Cooperation (ATLA 2021)

Cooperation Field	Partners
Agreement concerning Defence Equipment and Technology Transfer (10)	UK (2013), Australia (2014), India (2016), France (2017), Germany (2017), Philippines (2017), Malaysia (2018), Italy (2019), Vietnam (2020), Indonesia (2021),
Working Groups and Panels (5)	High Level Defence Equipment and Technology Cooperation Steering Panel (UK) Committee on Defence Equipment and Technology Cooperation (FRA) Committee on Export Control (FRA) Joint Working Group on Director-level Meetings on Defence Equipment and Technology Cooperation (ITA) Joint Working Group on Defence Equipment and Technology Cooperation (IND)
Exchanges (2)	Australia (Personnel, Marine Hydrodynamics)
Cooperative Research Projects (11)	UK (5), AUS (3), FRA (1), IND (1)
Memorandum on the Exchange of Classified Information on Defence Equipment and Technology (1)	Israel

Collaboration remains nonetheless mostly limited to smaller R&D projects and narrow technological fields, with most of the momentum coming from government rather than industry initiative. The agreements are thus only a preliminary step to establish Japan’s isolated defence industry as an international partner. While Keidanren is in favour of international cooperation,

the industry is also afraid of potential future competition and promotes domestic defence spending as most important tool to sustain the domestic industry. Continued protectionism at the same time obstructs the collaboration efforts, as international partners are frustrated and reluctant to engage further (Hughes 2019b, 90–91).

5.2.6. Networks

Agglomerations and Clusters

Japan has not developed dedicated defence clusters and the topic is not mentioned in policy papers. This is a result of its unified economy and the limited defence industry, shaped by monopolies and duopolies. Defence production is facilitated in shared factories. For example, in the early 1990s MHI was able to utilize 90 percent of its defence production facilities for civilian production as well, enabled by so-called “hotbed” facilities that allow the rapid switch to expand defence production if necessary (Hughes 2011, 458). Although a cluster exists for aerospace in Aichi prefecture, it would be an overstatement to define it as defence cluster (JETRO 2017).

The SDF’s internal research is primarily facilitated by ATLA’s five research and five test centres, all located in the vicinity of Tokyo (Kausal and Markowski 2000, 2-19). Nonetheless, the dominant part of defence R&D is conducted by private enterprises.

Civilian-Military Partnerships

Akin to clusters, civilian-military partnerships have received little attention, due to the unified nature of the Japanese economy. The 2015 “Innovative Science & Technology Initiative for Security” programme is the first to create partnerships between universities and the defence industry, but only time will tell in how far these become permanent (JMoD 2020, 428–429). Since 2019, ATLA participates in the Councils for Science, Technology and Innovation and for Integrated Innovation Strategy. These were established to explore further permanent collaboration between governmental agencies, industries and universities (JMoD 2020, 427).

As aforementioned, the Japanese university sector is reluctant to participate in defence R&D. By 2018, 46 of 135 Japanese universities had implemented a screening system to prevent defence R&D, with 30 allowing their researchers to apply for ATLA grants (Nature 2018). The only university receiving considerable funding, the University of Tsukuba, has been the centre of protests since (Naoki 2020). ATLA is thus encountering considerable opposition in its mandate to integrate university R&D with the defence sector.

The Amakudari Network

The close connections within Japan's defence sector have led to the rise of a military-industrial complex. The early compulsory retirement of SDF officials has led to a regular recruitment of officials by the defence industry. This "Amakudari" system is a crucial factor in the lobbying and collaboration that enables the non-competitive procurement system. In the mid-2000s, more than 700 former SDF personnel, including former high-ranking officers, were employed by major defence companies. These links have been cited as a major problem, resulting in repeated scandals involving corruption and overpricing during the 1990s and 2000s (Hughes 2008, 69–71). Since 2015, the re-employment of former SDF personnel is thus more strictly regulated (JMoD 2020, 414).

5.2.7. Policy Portfolio: Financial Policy

Japan's finance policy supporting its DIS dominantly relied on nurturing the defence industry through dependable sole-source and sub-contracts, and spin-offs in civilian products, presenting a policy of de-facto R&D subsidies (Bitzinger 2017, 17). This support was in part delivered through so-called Kokusanka projects that could have been acquired more cost-effectively abroad (Hughes 2019a, 424). While the defence budget was limited to 1 percent of the GDP, at the same time the policy of indigenous R&D and production presented a major cost factor. Indigenous R&D on average amounted to three times the cost for the acquisition of foreign systems (Alexander 1993, vi).

The lack of dedicated public funding for defence R&D was enabled by the close integration of defence and civilian commercial undertakings, and foreign technology transfers. In 1991, the Japanese defence sector was at the end of a boom phase that was driven by growing defence budgets and the SDF's rearmament due to the Soviet threat. In the latter half of the 1980s, defence stocks had vastly outperformed civilian counterparts, and several conglomerates established internal defence divisions and publicly outlined their involvement in defence contracts (Alexander 1993, 22). The potential to gain profits from both spheres incentivized enterprises to invest in respective R&D projects, specifically where spin-off and dual-use potential existed. Where this indirect encouragement was not sufficient, for example in the electronics sector, the JDA utilized cost-plus contracts to expand profit margins (Alexander 1993, 23–24).

The pressures resulting from declining budgets, lower procurement numbers, and the SDF's utilization of deferred payments, a practice outlined under acquisition policy, increased the need for additional funding methods from the early 2000s onwards. Although R&D in dual-use

technologies presented no direct problem, due to the spin-on effects on the Japan's DIB, the further utilization of them in the development of weapon systems became less attractive to companies.

In light of these increased costs, the overall defence expenditure grew from 6.23 percent of government expenditure in 1991 to 6.65 percent in 1995 but fell to 5 percent in 2011 and stagnated on this level. In absolute terms, the defence budget declined after a period of steep growth from 1997 onwards and only started to increase again under the Abe administration from 2012 onwards (Hughes 2019a, 403–404). After growth rates between 1 and 2 percent, it reached an all-time high in 2020 (Miki 2019a).

The SDF themselves are barely involved in supporting basic research and R&D with relevance for defence, as they lack the necessary budget. Instead, they rely on defence enterprises, while internal projects are limited to crucial undertakings enabling the former (Alexander 1993, 26–27). In the early 1990s, only 5 percent of all governmental R&D funding thus flowed into defence R&D (Samuels 1994, 321). Within the annual defence budget, only 2 to 3.5 percent have been spent on defence R&D (Hughes 2019a, 407–406). Expenditure on the acquisition of defence equipment has also fallen from 27.7 percent of the budget in 1991 to 15.9 percent in 2012. Since then, its share has hovered around 16 and 17 percent of the overall budget (Hughes 2019a, 405).

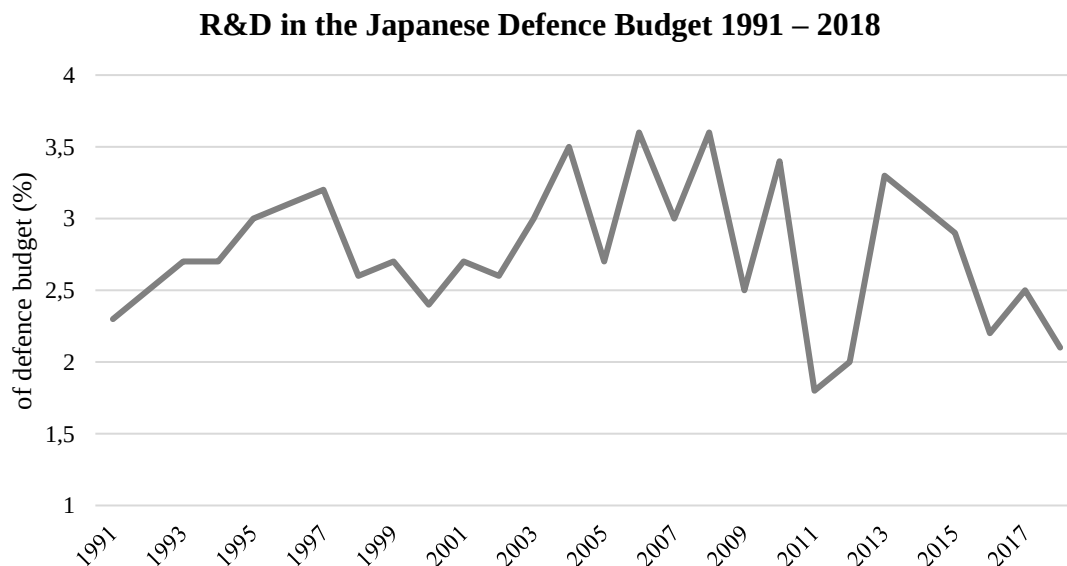


Figure 7 – R&D in the Japanese Defence Budget 1991 – 2018 (Hughes 2019a, 407–406)

Demand for new funding sources was the most important driver for easing arms export restrictions, but it has not unfolded as planned. Japanese defence enterprises have so far proven

to be too reluctant and inexperienced to compete in international procurement, and the high cost of their products has also hampered interest abroad (Hughes 2019a, 431–432). Only in 2020 did the company MELCO accomplish to sign the first major deal for the Japanese DIB, the supply of warning and control radars to the Philippines (Abe 2020). Despite this lack of major defence contracts abroad, the five biggest Japanese defence corporations have throughout the last twenty years been in the top 100 of biggest defence enterprises in the world (SIPRI 2021a).

New funding opportunities have emerged through Japan's militarization of its space and cyber sectors (Sakaki and Maslow 2020, 3). While these emerging fields have become more relevant for defence, space programmes are funded by a separate budget from METI. Japanese defence enterprises are strongly engaged in the sector, with MHI publicly mentioning the advantages to the DIB (Pekkanen 2013, 3–5). Although the government has become increasingly reluctant to bear the increased costs associated with the domestic production of joint projects such as the F-35, it recently backtracked, resorting again on MHI to assemble the aircraft (Miki 2019b).

The Japanese economy has proved highly efficient in the utilization of funding for both civilian and defence R&D undertakings. Defence enterprises themselves do not distinguish between defence and civilian technologies (Samuels 1994, 322). Thus, the R&D projects funded by MITI, the Science and Technology Agency, and the Japan Key Technology Centre had major relevance for dual-use (Samuels 1991, 55–56). The criticism ImPACT programme for its relevance for defence, as mentioned before, displays the lack of public attention regarding the recipients of public R&D funding in Japan's integrated economy (Sakaki and Maslow 2020, 11).

The “Innovative Science & Technology Initiative for Security” programme launched in 2015 is Japan's first dedicated defence R&D programme. It is a competitive bidding programme funding basic research in advanced civilian technologies that can be utilized for defence (JMoD 2020, 428). Beginning in, 2020 ATLA has allocated funding from the defence budget to support and maintain SME participation in the defence sector (Grevatt 2019).

5.2.8. Policy Portfolio: Acquisition Policy

The JDA's procurement policy, traditionally, deliberately limited competition within the procurement process. The JDA Equipment Bureau managed competition for defence contracts in collaboration with MITI, Keidanren, and the Japan Association of Defence Industry (Samuels 1994, 323). In the first half of the 1990s, close to 90 percent of procurement value was handled through non-competitive or limited contracts (Hughes 2019a, 422–423). Competition between defence enterprises thus manifested through the lobbying of public officials and government

bureaucracies. Indeed, the close links between DPA and DIB enabled defence enterprises to initiate R&D undertakings before a budget was even allocated for the respective acquisition. Already in the first tender phase, only a limited number of enterprises was invited to submit proposals for a new project (Alexander 1993, 20–21).

As the JDA had to approve subcontractors as well, all invited companies would receive contracts. This was a deliberate policy to nurture the Japanese DIB and safeguard their existence in face of low production volumes (Samuels 1994, 323). Over time, this established a work division and subsequent technological path dependency, where enterprises focused on specific components and manufacturing steps in their technological fields (Alexander 1993, 20–21). The collaboration between the Japanese DIB and governmental bodies went as far as that defence enterprises themselves often defined equipment standards (Samuels 1994, 323).

Pricing was based on cost-plus contracts that incorporated profit ratios, with a limit of 6.5 percent for profits (Hughes 2011, 457). Their level was based on moving averages of general defence industrial behaviour, thus in the early 1990s the defence industry still profited from the 1980s boom period (Alexander 1993, 23–24). An important element introduced in the 1990s to overcome budget constraints were deferred payments, stretching the payment of major contracts over multiple fiscal years. Nonetheless, the practice clogged budgets and prevented short-term acquisitions, as in some years up to 60 percent of the budget were utilized for deferred payments (Hughes 2011, 460–461).

Beginning with the NDPG 1995, and featuring prominently in the 2004 and 2010 NPDGs, the reduction of costs in procurement and life-cycle management became a central element of acquisition reform (JSC and Japanese Cabinet 1995; 2004; 2010). Prices and efficiency indeed increased in the subsequent years, with prices per unit dropping between 6 and 12 percent between 1997 and 2000 (Hughes 2011, 465). Since 1998, reforms were implemented not only to reduce costs, but also to increase transparency for non-competitive and limited contracts, an incentive system for reducing unit prices, and the utilization of ISO standards (Kausal and Markowski 2000, 2-28–2-29). Transparency reforms gained even more attention after two corruption scandals in 2007 that highlighted the close relationship between industry and JMoD (Hughes 2011, 466).

Most importantly the JMoD has strived to introduce more competition in its contracts and thus raise efficiency. Major procurement projects such as for submarines have been opened for competition (Hughes 2011, 466). Since 1999, competitive contracts have overtaken limited and non-competitive ones, as displayed in Figure 8. While in the 1990s Japanese procurement was

dominated by limited and non-competitive contracts, since then there are less than 10 limited contracts each year. Nonetheless, when looking at the monetary value, after a brief dominance of competitive contracts in 2010 the trend has reversed. Competitive tendering is thus primarily utilized for smaller acquisition projects (Hughes 2019a, 422–423).

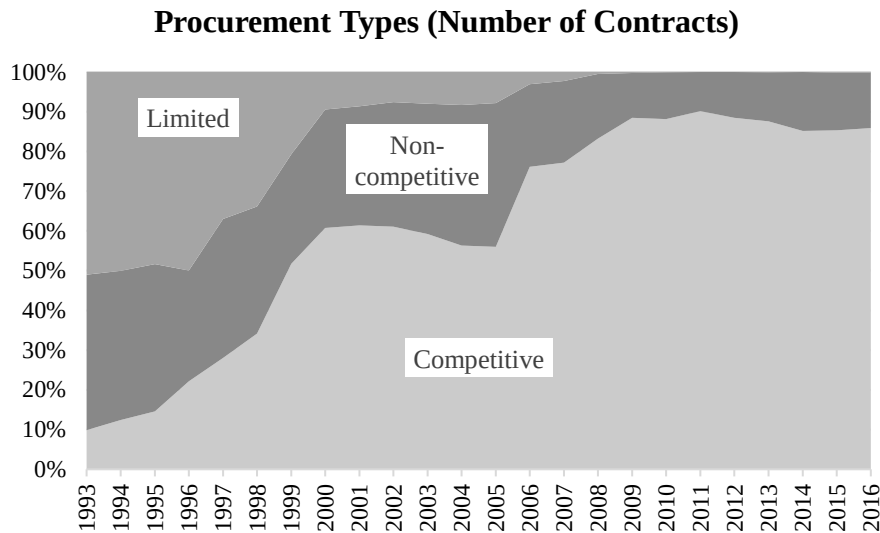


Figure 8 – Procurement Types in Japan in Absolute Numbers (Hughes 2019a, 422–423)

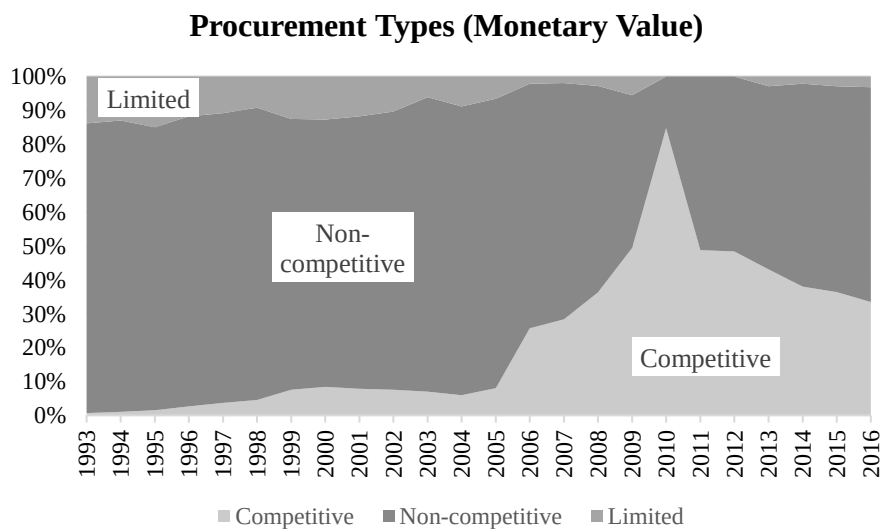


Figure 9 – Procurement Types in Japan in Monetary Value (Hughes 2019a, 422–423)

In 2007, JMoD thus created the Comprehensive Acquisition Reform Committee, and the Contractual Systems Study Groups in 2010 (Hughes 2019a, 431). While reforms started with the 2010 NDPG, the 2014 Strategy on Defence Production and Technological Bases and the creation of ATLA initiated the main phase of reforms. Since then, reforms have focused on long-term contracts, incentives, transparency, project management, and FMS rationalization.

To improve long-term contracts, the Public Finance Act was adapted to extend planning periods from five to ten years, thus ensuring budget and planning security for defence enterprises. To prevent future scandals of collusion and overpricing, additional supervision, inspection, investigation systems, as well as additional penalties, are in the process of introduction. To that purpose, ATLA is utilizing both internal and external auditing. Efforts to standardize equipment have been undertaken by defining product families, standardizing specifications, and adapting joint procurement for equipment used by more than one service branch.

For contracts that cannot be fulfilled in competitive bidding due to the oligopolistic nature of Japan's DIB, limited tendering and non-competitive contracts, additional transparency and fairness measures are to be implemented. The 2020 Defence White Paper outlines continued efforts to establish a comprehensive evaluation bidding system, which takes additional factors into account, aside from price alone. For example, cost reduction has been introduced as an indicator, in order to reduce costs during the mass production stage. In 2020, an incentive contract system was implemented that rewards companies when cost reductions have been fulfilled.

Project management features high in reform undertakings. ATLA already concentrates project management in a specific department. The measure follows the Acquisition Strategy and the Acquisition Plan that aim to improve acquisition policy and life-cycle costs through this central management of long-term projects. The undertaking follows previous reforms introducing cost and schedule management, and methods for costs estimation. To this end a database has been created that outlines previous procurement prices, which should enable improved accuracy in cost estimations (JMoD 2020, 430–433).

Following the Kokusanka policy, defence procurement was dominantly focused on domestic industries. Between 1991 and 2013, the ratio of domestic procurement hovered at 90 percent. With the abandonment of Kokusanka, the ratio dropped to 70 percent in 2016 (Hughes 2019a, 426–427). Despite the officially published high-levels of domestic procurement, these only display the DPA's direct procurement. Already in the early 1990s, defence enterprises themselves estimated that up-to 40 percent of the value of Japanese defence acquisitions was supplied by sub-contractors in the US (Alexander 1993, 24).

As aforementioned, the licencing option has dried up in the 1990s, and international cooperation is since seen as substituting tool to enable technology transfers and to reduce costs. To improve foreign acquisitions from the US, ATLA and the US Defence Security Cooperation Agency have held meetings since 2016. In 2019 the Group for Coordination of FMS Procurement was

created within ATLA to formalize this exchange, and in order to overcome problems of efficiency such as delayed deliveries (JMoD 2020, 434).

5.2.9. Policy Portfolio: Human Resource Policy

Due to Japan's dependence on R&D conducted by private defence enterprises, and their dual nature, human resource policy has received little attention from the government. Defence and civilian undertakings remain closely integrated. Military systems are produced within the same facilities as civilian products, and the workforce is employed for both as well. The major defence industrial conglomerates have no dedicated recruitment or incentive programmes for their defence units. Instead, the workforce is employed for both civilian and defence contracts, including also R&D conducted in internal laboratories or research facilities (Alexander 1993, 23). This has not changed during the assessment period (JDA 2005, 79; JMoD 2014b, 338; JMoD 2020, 430–431). This lack of attention is due to Japan's favourable situation regarding skilled labour, with the industry having no problems recruiting personnel (McIntosh 2012, 54).

Despite the loss of 15 percent of engineers and 9 percent of R&D technicians in the defence sector between 1995 and 2000, due to the decline in defence revenues, no official policies have been implemented to mitigate the problem (Hughes 2011, 473). JMoD's attention to recruitment has been limited to internal demands, where it is recruiting university graduates for ATLA and other JMoD bodies. Civilian personnel are recruited through the "Recruitment Examination for Comprehensive and General Service National Public Employees", conducted by the National Personnel Authority. Defence personnel is recruited through the "Recruitment Examination for Ministry of Defence Specialists". Through these exams, personnel are recruited for internal R&D, procurement management, and other services (JMoD 2020, 407). JMoD also promotes the recruitment of women for these purposes (JMoD 2020, 419).

Special attention is given to the recruitment of personnel with skills in project management. In 2016, a special research officer system was established to recruit university professors to introduce best practices from business administration and civilian economics to the procurement system (JMoD 2020, 430–431).

Since 2015, the re-employment of former SDF personnel is more strictly regulated due to the problematic nature of the Amakudari Network and related corruption scandals. Two boards, consisting of external professionals in the JMoD and the Cabinet, supervise the re-employment of retired personnel. Instead of a previous approval system, three regulations prohibit the employment by entities that were formerly in relation to the SDF official (JMoD 2020, 414). Additionally, an SDF Personnel Support Association provides consultation to help legal re-

employment in the civilian sector (JMoD 2020, 411). It remains unclear though how effective the new measures are in curbing the practice of Amakudari (Hughes 2019a, 427–428).

5.2.10. Summary

Of the three case studies, in 1991 Japan stood out as the country with the most sophisticated DIB and the most integrated economy. Policy reforms have primarily addressed already existing systemic failures in the scope of interaction, which were aggravated by the increased demand for innovation and the breaking away of knowledge transfer opportunities. In 1991, the Japanese DIB was already integrated with the civilian sector, with major defence enterprises being identical to major civilian enterprises. This lack of a delimitation resulted from deliberate policy decisions and acted as boon to the further development of the sector.

Reforms have been shaped by the overarching political shift towards a “normalization” of Japan’s defence policy. This is signified by the level-up of the Japanese Defence Agency to a full Ministry of National Defence in 2007. In addition, timespans between updates of the National Defence Programme Guidelines have shrunk and additional planning tools for armed forces development and defence innovation have been created.

Organizational reform has occurred in line with international developments, as described in sub-chapter 2.5.3. Subsequent to department mergers in the 1990s and the 2007 formation of JMoD, in 2015 DPA tasks were centralized in the Acquisition, Technology and Logistics Agency (ATLA). ATLA has been formed outside of the ministry with a civilianized character. Previous high levels of influence by civilian ministries were already reduced with the 2007 reform.

Japan’s actor landscape has changed little during the assessment period, comprising of a number of major enterprises primarily active in the civilian market and specialized defence SMEs. Until 1995, the DIB had not been a topic in the NDPG at all. Policy goals for the DIB have been limited, as neither an opening of the sector for civilian enterprises nor other major governmental interventions were necessary. Due to the close management of defence procurement by MITI/METI, and the linked work separation, Japan’s defence enterprises have developed a strong technological path dependency. The market is thus shaped by policy induced monopolies and duopolies. The bulk of R&D is handled by private enterprises themselves, with ATLA and the preceding TRDI acting primarily as enabler.

Akin to its integration of the civilian and defence domains of its economy, Japan has never developed specified defence agglomerations or clusters. Recent efforts for establishing defence

R&D activities at universities remain limited to a few universities. Unwanted linkages present in the so-called “Amakudari Network” have been the focus of anti-corruption and transparency efforts since at least the early 2000s, but their effect remains unknown.

In the scope of the Japanese policy portfolio, changes have targeted aforementioned systemic failures. Linkage policy: ATLA has strived for strengthening defence-university linkages but encounters considerable resistance from academics opposing involvement in defence undertakings. To enable and strengthen foreign linkages, in 2014 the ban on technology transfers was lifted. While being able to sign agreements with Western and Southeast Asian partners, collaboration remains hampered by protectionism and is limited to smaller undertakings.

Financial policy: With a stagnating defence budget, but rising unit and R&D prices, new funding methods for the Japanese DIB have been a permanent topic of policy discussion. The lifting of the arms export ban aimed to open such new funds for the DIB, but defence enterprises have not yet been successful in international tenders. This is primarily due to high prices and the enterprises’ lacking experience. There is little dedicated public defence R&D funding, but the DIB profits from general R&D funds that do not distinguish between civilian and defence R&D. For the first time, de-facto defence funding programmes have been established for university outreach, as well as for promoting civilian technology spin-on.

Acquisition policy: Japanese acquisition policy have been characterized by the nurturing policy, manifesting in “Kokusanka” projects incorporating work shares to engage all important defence enterprises. This practice, implemented through MITI/METI has ended with the establishment of JMoD and subsequent policy reorientation. Nonetheless, it still shapes the availability of contractors. Acquisitions have been hampered by the lack of financial resources, resulting in a practice of deferred payments during the 1990s. Thus, reform has centred on providing incentives for price reductions and life-cycle management. This also encompasses efforts to improve foreign acquisitions through the US FMS programme.

Following efforts to increase competition, the bulk of acquisition projects is handled through competitive tendering. In contrast, the bulk of value, bundled in a few major contracts, is still handled through non-competitive supplier selection. The abandonment of Kokusanka has also further decreased the levels of domestic sourcing and increased reliance on components from US suppliers.

Human resource policy: Resulting from the limited role of public actors in the DIS, human resource policy has not been a topic for policy reforms. JMoD and ATLA recruit their personnel

through the standard examinations for public service and source expertise for specific topics, such as programme management, through a special research officer system. There are no talent recruitment schemes for abroad.

Institutional reform during the assessment period has been limited. Ownership and investment regulations, limiting foreign influence both by law and by MITI/METI policy, were again strengthened in 2020. Likewise, MITI/METI and now ATLA have managed market entry through acquisition policy. IPR regulations have been liberalized in 2002 but remain ambiguous. In 2016, ATLA announced the formulation of an “open and closed” strategy for the classification of defence R&D results, but its state of implementation remains unclear.

Japan has approached arms and technology exports very strictly, primarily from the perspective of proliferation and domestic pacifism. Nonetheless, in 2014 exports have again been legalized and are handled by MITI/METI. This followed loophole creations for the collaboration with the US enterprises during the preceding three decades. Tackling one of the most serious systemic failures, the lifting aims to both enable foreign technology transfers through collaboration and open a new funding source for the DIB.

The trends of the transitional defence sector bear limited relevance for the Japanese DIB, as it was not separated from the rest of the economy. Organizational reforms have focused on “normalization” and developed in line with international trends of DPA centralization. No additional organizations have been established to promote issues such as linkages. With a stable actor landscape, policy reform has focused on the three major systemic failures of the Japanese DIS: foreign collaboration, defence-university linkages, and financial resources. Success in alleviating them has been quite limited so far. Despite that, for now it appears the Japanese government has been able to forestall the feared “Galapagos effect”. While sacrificing some of its defence industrial independence in favour of collaboration with US industries, the Japanese DIS retains its ability to supply SDF demands.

5.3. Republic of Korea

5.3.1. Policy Portfolio: Overarching Tenets and Planning Instruments

South Korea's defence industrial policy has been shaped by techno-nationalism and Koreanization since the early 1970s. Following the Nixon-shock of US American realignment in 1971, the Korean government developed the "Yulgok Project" (1974 – 1992), focused on developing an indigenous DIB that would make the Armed Forces of the Republic of Korea (AFROK) self-sufficient. It entailed the promulgation of the institutional framework that guides South Korean defence industrial policy to this day (Han 2006, 113–114). Since then, the Republic of Korea's (ROK) defence industrial policy has been guided by the ambition to reduce dependency on arms imports, boost overall economic development by utilizing defence production as import-substitution and driver of industrialization, and to raise the ROK's status as geopolitical player in East Asia (Bitzinger 2019, 378; MND 2009, 201).

This goal has not been fully achieved yet, but the Korean defence industry has emerged as a major arms exporter and is able to provide finished, advanced military systems (Han 2006, 113). Since the first decision to pursue Koreanization, the Korean Ministry of National Defence (MND) has attempted four major reforms designed by respective governments. These reforms have primarily targeted the overall command and organizational structure of AFROK but have also the DIB in the context of modernization. None of the reform attempts were fully implemented. Despite not delivering the expected changes, South Korea has made major advances in defence modernization and indigenisation.

South Korean defence industrial policy was based on four tenets since its conception in the early 1980s. These were (Moon and Paek 2010, 5):

1. the designation of defence contractors, who in turn receive access to defence procurement, including guarantees on governmental purchases;
2. the deliberate specialization of defence contractors on technological fields, thus establishing monopolies and oligopolies;
3. a guarantee for covering production costs by the government;
4. and accesses to a special "Fund for the Promotion of the Defence Industry".

These tenets have received increased scrutiny and were ultimately abolished during the 2000s and 2010s (Moon and Paek 2010, 5).

After the second reform attempt failed in 1988, two more narrow reforms were proposed by the MND in 1993 and 1998, but eventually not implemented. In 2006, the National Defence Reform

2020 was presented as the third major reform, with the most meaningful impact on the Korean DIS. Its most prominent goals were the reduction of AFROK's manpower and supplementing modernization efforts, and civilianizing the MND (Han 2006, 114–117). Included in these overarching goals was a complete overhaul of the South Korean DPA organization structure and the establishment of a long-term acquisition perspective (Han 2006, 127–128).

In line with the increasing sophistication of the ROK DIB, the defence industry has been identified as new engine driving economic growth since the late 2000s. This was motivated by the successes in defence exports and spin-off effects, but also by studies that identify an above-average impact of defence industrial spending on the overall economy (MND 2009, 203–212). By the early 2010s, the ROK DIB had become mostly self-sufficient in producing its own military systems (Bitzinger 2019, 380).

The 2006 reform plan underwent two revisions. The first, in 2009, limited both the troop cuts envisioned and more importantly decreased the defence budget, due to the 2008 financial crisis (Korkmaz and Rydqvist 2012, 56). Resulting from increased North Korean aggression in 2010, the sinking of the warship Cheonan and the shelling Yeonpyeong Island, the Defence Reform 307 Plan was introduced a year later. It primarily affected capabilities and command structures (Bennett 2011). Considering its narrow scope, the 307 Plan was a second adaptation to the previous reform plan, rather than a substitute (Korkmaz and Rydqvist 2012, 57). Both thus did not directly affect the ROK defence industry, but they had a direct impact due to the reduced budget for acquisitions.

Acknowledging the protracted implementation of the 2005 reform, in 2018 the government proposed the Defence Reform 2.0. It sets the goal for the AFROK of being a “strong army”, capable of tackling the whole spectrum of traditional and hybrid threats. In order to overcome challenges created by resource shortages and the technologization of the modern battlefield, military-civilian partnerships and the potentials of the Fourth Industrial Revolution are to be utilized (MND 2019, 50–51).

The reform goals outline transparency, competitiveness, and acquisition efficiency efforts. On the one hand, a clearer separation of industry and politics is envisioned through hiring restrictions and improved oversight mechanisms. On the other, the reform strives for a speedier acquisition process, the implementation of strategic technology planning, and the utilization of advanced technologies developed by civilian firms (MND 2019, 131–155). The ROK defence sector has seen the steady implementation of new laws and regulations aimed at strengthening reform undertakings and nurturing policies. These include the Defence Acquisition Programme

Act in 2006, and the Act on the Development and Support of the Defence Industry and the Defence Science and Technology Innovation Promotion Act of 2021.

Planning Instruments

South Korean defence planning is formulated in a hierarchical system of long-, mid-, and short-term strategies and plans. Long-term plans are regularly updated or newly published in a 5-year cycle, in hand with the change of administrations. The Defence Reform Basic Plan (DRP), which has no determined time-horizon, is to be updated every 5-years in accordance with the National Defence Reform Act. The National Security Strategy (NSS), formulated by each administration, is not a designated planning document itself. Thus, even long-term policy documents are at least updated every 5 years.

In accordance with the National Defence Reform Act, the Defence Reform Basic Plan has to undergo a mandatory review and update every 5 years. Together with the Defence Intelligence Estimates, the NSS provides the priorities for updating the defence planning documents themselves. The Defence Reform Basic Plan, the Defence Planning Guidance, the Force Enhancement Budget, as well as the Mid-Term Defence Plan, are documents steering South Korean defence acquisition policy and reform. None of the documents displayed are available to the public, but its contents are outlined in respective press conferences and in the bi-annual defence white paper since 1988 (Boese 2000, 10–18).

Table 25 – The ROK’s Military Planning Cycles (Boese 2000, 10–18)

	Name	Content	Updated	Time-horizon
long-term	National Defence Policy	national defence objectives	5 years	15 years
	Joint Military Strategy	military strategic objectives and concepts		
	Defence Science and Technology Promotion Policy	policy direction for advancement of DST		
	Defence Reform Basic Plan	development and adaption of defence capabilities	3 yr.	
mid-term	Joint Strategy Objective Plan	force development requirements	annually	3-7 years
	Defence Planning Guidance	budget and resource allocation priorities		1-7 years
	Mid-term Defence Plan	link between force and capability requirements and fiscal resources		5 years
	Basic Plan for Fostering the Defence Industry	defence industry management		

	Name	Content	Updated	Time-horizon
short-term	Joint Strategy Capability Plan	links between capabilities and strategic tasks	annually	1 year
	Force Operating Budget	MND budget request		
	Force Enhancement Budget	DAPA budget request (acquisition and supporting programmes)		
	Defence Science and Technology Promotion Action Plan	DST programmes		

Under the Defence Acquisition Programme Act promulgated in 2006, specific policies for the field of science and technology are also implemented. These include the Defence Science and Technology Promotion Policy by the MND, which is the core document for steering defence S&T policy. Since 2019, the document is reviewed by the Presidential Advisory Council on Science and Technology, highlighting both its importance and integration in national S&T planning.

Together with the Defence Agency for Technology and Quality's (DTAQ) 3-year Defence Science and Technology Survey Report, it guides the Defence Science and Technology Promotion Action Plan and the Core Technology Planning Sheet. These guide the mid-term planning and budget allocation. The action plan is developed annually by DAPA and outlines the actual programmes. (DTAQ 2020, 15; Yang, Hwang, and Kim 2020, 2). Core technologies are essential technologies, which cannot be obtained through technology transfers from abroad (Jae-ok 2010, 199).

Since 1993, the MND implements the Basic Plan for Fostering the Defence Industry, which includes R&D and acquisition activities, as well as the promotion of domestic production. The current plan runs from 2018 to 2022. Since 2011, the ministry also develops the Basic Plan for Defence Informatization, which covers related R&D activities. The current one targets the period of 2019 to 2033 (Act on Special Measures for the Defence Industry 2001, Art. 3; Act on Defence Informatization 2014, Art. 5).

5.3.2. Organizations

In 1991, implementation of the ROK's defence procurement tasks was managed through the Programming, Budgeting, Execution and Evaluation System (PPBEES). It was delegated to a number of bureaus under the MND Vice Minister of Acquisition and Defence, the Joint Chiefs of Staff (JCS), and external bodies subsidiary to the MND. As displayed in Table 26, this

involved not only various suborganizations, but also additional councils within the JCS and the MND. Furthermore, the inter-ministerial level Defence Improvement Committee was involved in the overall process, specifically for budget authorization and the re-evaluation of acquisition decisions (Hutchinson 1998, 145–158). The Acquisition Development Office (ADO) had only been established in 1991, when the former Defence Industry Division became ADO. In 1997, programme management responsibility was delegated to the respective bodies within the service branches (Kausal and Markowski 2000, 3-17–3-22).

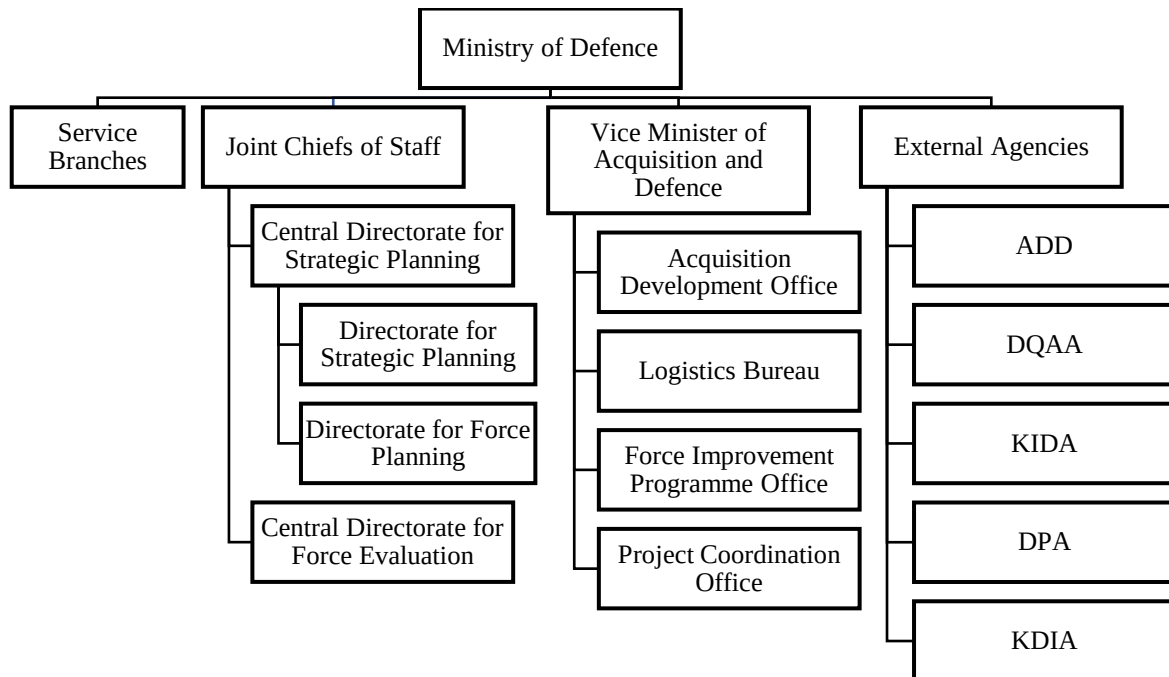


Figure 10 – ROK Defence Acquisition Organizations 1991–1999 (Hutchinson 1998, 148)

The PPBEES System was shortened from nine to six phases in 1997. In 1999, ADO became the Defence Acquisition Office (DAO), following an attempt to further rationalize and streamline the acquisition and procurement process. Although its set-up remained similar, encompassing five bureaus, DAO received overarching responsibility over acquisition projects, foreign procurement, industry oversight, as well as the execution of the R&D and investment budgets.

Its bureaus also had supervision over the three external agencies: The Agency for Defence Development (ADD), the Defence Procurement Agency (DPA), and the Defence Quality Assurance Agency (DQAA). On the same horizontal level within the MND, the Policy Office and the Planning & Management Office had been set-up. These offices were responsible for drafting the Mid-Term Defence Plan and drawing-up the defence budget (Kausal and Markowski 2000, 3-17–3-24).

Table 26 – Organizations involved in the PPBEES implementation 1991–1997 (Hutchinson 1998, 145–158)

PPBEES Phase	Organizations	Councils
Operational Capability Requirements	Service Branches	
Requirement Planning and Determination	JCS Central Directorate for Strategic Planning (tracks weapon system requirements) JCS Central Directorate for Force Evaluation	JCS Joint Strategic Council (decides weapon system requirements)
Testing and Evaluation	JCS Central Directorate for Force Evaluation (oversight) Defence Quality Assurance Agency (DQAA)	
Procurement Source Decision	MND Acquisition Development Office (ADO)	MND Working Level Acquisition Review Council (WLARC) MND Acquisition Review Council (ARC) MND Expanded Acquisition Review Council (EARC)
Contract Negotiations	Defence Procurement Agency, under guidance of ADO	
Comparative Evaluation	MND Deputy Minister for Acquisition and Technology Acquisition Development Office (ADO)	

Until the launch of the National Defence Reform 2020 in 2006, the AFROK's DPA structure remained nonetheless distributed across eight organizations. As mentioned above, they were located under the Ministry of National Defence (MND), the Joint Chiefs of Staff (JCS), the Defence Procurement Agency (DPA), and the service branches. These included procurement bureaus of the Army, Navy and Air Force, which primarily were involved in stating requirements and choosing contractors. The Offset Trade Committee managed South Korea crucial offset policy, outlined in chapter 5.3.5.

Under the JCS, the Acquisition Deliberative Committee played a major role in selecting potential weapon systems and deciding the final methods of acquisition (domestic, licence, import). Final decision making rested with the JCS Joint Strategic Council. The JSC bodies also managed testing and evaluation (Han 2006, 127–128). The MND Defence Procurement Agency was responsible for finalizing procurement, by deciding on the choice of systems with the service branches and preparing contracts for signature. Domestic defence R&D undertakings

were concentrated in the Agency for Defence Development (ADD), which is described as an actor in the respective chapter (Choi 1998, 186–188).

The Defence Reform 2020

In 2006, the Defence Acquisition Programme Administration (DAPA) was created as a separate agency under the MND. This was conceptualized to boost the efficiency and transparency of the Korean DPA structure. It entailed the consolidation of the eight aforementioned players into create DAPA (Han 2006, 127–128). DAPA was tasked with overseeing the budget and mid-term national defence plans, and of acquisition, administrating tests and evaluations of new systems, and of supervising ADD and DTAQ.

Thus, all undertakings within the NDO were centralized and externalized under DAPA, effectively uniting the areas of R&D under ADD, of S&T planning, and testing under DTAQ, under one roof (Watanabe 2014, 1–2). DAPA therefore controlled major parts of defence acquisition, from planning, budget location, R&D and procurement, to testing, evaluating and fielding new systems (MND 2015, 180).

DTAQ is the organization responsible for administrating defence S&T planning and technology information management. It had evolved out of the Defence Quality Inspection Agency, founded in 1981, which was responsible for the quality of AFROK defence supplies. In 1989, it became the Defence Agency for Quality Management, with additional authorities for quality assurance. Through the 2006 reform, it was renamed DTAQ and received its role as central planning body (DTAQ 2021). In 2021, the Institute for the Promotion of Defence Industry and Technology was established as affiliated organization of DTAQ, following the Act on the Development and Support of the Defence Industry in the same year. It took over the task of supporting the industry in the scope of export promotion and localization of munitions (Kim 2021).

The creation of DAPA in 2006 was not welcomed by the MND, which opposed the loss of its authorities (Korkmaz and Rydqvist 2012, 74). Furthermore, while DAPA was primarily focused on domestic procurement, for the MND US imports were often the more effective path to fulfilling capability gaps. After two struggles over the acquisition of new attack helicopters and the failure of a new torpedo programme, the suspicion of collusion between DAPA and the defence industry led to a new reform. It allowed the MND to push for a redistribution of authorities, which was implemented in 2014.

The reform limited DAPA's autonomy from the MND and brought ADD and DTAQ back under MND supervision. Thus, planning, R&D, and testing and evaluation were relocated under the MND, while the JCS regained authority over deciding on the requirements proposed by the service branches. After the reform, DAPA's role was hence limited to budget allocation and coordinating R&D and procurement, as well as overseeing fielding and deployment. In light of collusion allegations, the ratio of civilian employees in DAPA was increased and the enforcement on the ban of reemployment in the defence sector was strengthened (Watanabe 2014, 2–5; MND 2015, 180–182).

There is a number of additional sub-organizations involved in the promotion of defence technology and the facilitation of civil-military links. The most important of these is the Institute of Civil-Military Technology Cooperation (ICMTC) that was founded as affiliated body of ADD in 2014. It has the responsibility for implementing the Civil-Military Technology Cooperation Program. The programme comprises of efforts to promote bi-directional technology transfers between the civilian and defence sectors. The institute was created through the merger of ADD's Civil-Military Technology Cooperation Centre, responsible for dual-use projects, and the Defence Technology Business Centre, responsible for technological spin-offs. Thus, it represents the centralization of civil-military technology transfer coordination in a single body (ICMTC 2021).

To support the organization of conventions, exhibitions, and events, in 2015 the MND established the non-profit Defence MICE Institute (DMI). It hosts major defence conventions, supports the industry in creating their own events, and supports SMEs (DMI 2020). The 2018 Defence White Paper also announced the creation of a separate Defence Technology Planning and Evaluation Institute, responsible for technology forecast and planning (MND 2019, 135). In 2021, it was established as the Korea Research Institute for Defence Technology Planning and Advancement (KRIT) (Grevatt 2021a). Its mandate is to for “planning, managing, and assessing defence technologies, as well as fostering the defence industry and supporting its exports” (KRIT 2022).

Civilian Organizations

The interlinked nature of civilian and defence R&D investment means that there is no distinct delimitation of funding sources or recipients. Overarching technology fields such as aeronautics and other core technologies are associated with defence R&D (Jae-ok 2010, 198). 36 ministries and government bodies are involved in the funding of R&D projects, the three biggest among them being the Ministry of Science and ICT (MSIT), the Ministry of Trade, Industry and Energy

(MOTIE), and DAPA. Together with the Ministries of Education and SMEs and Start-ups, these five organizations spend more than 80% of the government R&D budget (KISTEP 2020, 46–47).

MOTIE and DAPA are the biggest investors into civilian-military technology cooperation (Lundmark 2016, 134). MOTIE, the Ministry of Economy and Finance, MSIT, and their preceding ministries have been directly involved in financing defence and dual-use R&D projects, as well as managing the defence industry (Lee and Markusen 2003, 235; Jae-ok 2010, 200).

The Defence Acquisition Programme Act of 2006, amended annually since, formalizes the cooperation of civilian ministries for defence acquisition and R&D. These include MOTIE, MSIT and the Ministry of Strategy and Finance. Their ministers form the Defence Acquisition Program Promotion Committee under chairmanship of MND and DAPA. MOTIE is integrated in supervising the defence sector with DARPA, specifically for the designation and classification of defence contractors and materials (Defence Acquisition Programme Act 2018, Art. 9). The Promotion of Technology Projects for Joint Civilian and Military Use Act also designates MOTIE as central civilian player in managing civil-military technological promotion (Act on the Promotion of Technology Projects for Joint Civilian and Military Use 2018, Art. 3).

DAPA is also a member of the Korea Council of R&D Funding Agencies (CORFA), which coordinates R&D planning and spending. This highlights the integration of defence R&D in the overall R&D management environment in South Korea (KISTEP 2012). The Korean Institute of S&T Evaluation and Planning established the Korea Advanced Research and Programme Accelerator (KARPA) in 2020. Although KARPA was created as a civilian body to promote disruptive innovation, it is mirrored on the US American DARPA and hence will likely be involved in defence R&D as well (KISTEP 2020, 147).

The Presidential Office and the National Assembly take an elevated role in the South Korean DIS, as they are integrated in the annual policy planning cycle. Aside from the defence budget, both have to approve the Defence Reform Plan. The former also has to directly approve the Midterm Defence Plan (Boese 2020, 13–18). Until 2006, defence acquisitions exceeding 5bn. won had to be approved by the president (Choi 1998, 177). Since then, the Enforcement Decree of the Defence Acquisition Programme Act only requires the minister of DAPA to report to the ROK president and the MND minister on projects with “a large budget or ... great impact on national policies” (2019, Art. 5 (2)).

The Korean Intellectual Property Office is also involved in the South Korean DIS, as it decided in consultancy with the MND, since 2006 with DAPA, on the classification of patents relevant for national defence (Enforcement Decree of the ROK Patent Act 2017, Art. 11). MOTIE is the central government agency in administrating the ROK's export controls, as well as in assisting enterprises through export promotion. In 2004, a Strategic Goods Trade Information Centre was set-up within the Korean International Trade Association. In 2007, it was established separately as a public agency, the Korea Strategic Trade Institute (KOSTI). KOSTI supports the implementation of controls and identification services (KOSTI 2021).

5.3.3. Actors

The impacts of the Yulgok project's deliberate separation of defence and civilian sectors, as well as the designation of firms as monopolistic suppliers, still have an important effect on the actor landscape (Weitz 2014, 48; Bitzinger 2019, 384). Notwithstanding their monopolies, companies were not permitted to specialize solely in defence production, with defence being limited to 30% of overall production. They thus have remained strongly engaged in the civilian market (Lee and Markusen 2003, 230). The industry's sophistication has rapidly increased since the decision to promote indigenization through the Yulgok project. While initial efforts focused on ammunition and small arms, since then the defence industry has evolved and produces a wide array of sophisticated weapon platforms (Moon and Lee 2008, 117–118).

The South Korean defence sector has continuously been affected by overcapacity. Throughout the 1990s, the capacity utilization rate hovered around 55 percent (Lee and Markusen 2003, 234). In the 2000s, the rate increased to 60 percent, but has not increased significantly since (Bitzinger 2019, 390). It continued to hover between 60 and 70 percent since, which indicates that the defence sector is relying on foreign contracts (Jang, Min, and Ann 2015, 28; Jang, Song, and Kim 2019, 11).

In 2013, nearly 90% of defence production and more than 75% of employees in the defence sector were concentrated in 50 companies (Jang, Min, and Ann 2015, 21). The South Korean defence market has traditionally been dominated by a few major companies that are subsidiaries of chaebols. Chaebols are centralized conglomerates that were founded, and are still often owned, by one family. They are characterized by interlocking ownership structures and usually have a regional focus within South Korea (Bitzinger 2019, 381). Although the defence sector is predominantly in private hands, public financial institutions have invested in major contractors. For example, the government holds 27 percent of Korea Aerospace Industries (KAI)

and 50.4 percent of Daewoo Shipbuilding & Marine Engineering (DSME), although the latter is about to be sold to Hyundai Heavy Industries (HHI) (Bitzinger 2019, 384).

While the characteristics of the classic South Korean defence sector have not changed much during the assessment period, the actor landscape has shifted continuously. The decline of the defence industry in the 1990s, due to lacking budgets, led to the bankruptcy of several smaller firms and of one major actor, Daewoo, in 1999 (Lee and Markusen 2003, 225). Samsung exited the business by selling its defence subsidiaries to Hanwha Group in 2015 and 2016 (Han 2016; Bitzinger 2019, 383).

The aerospace sector, dominated by Samsung Aerospace, Daewoo Heavy Industries Aerospace Division, and Hyundai Space and Aircraft Company, was exemplary for the redundancies and inefficiencies created by the specialization and nurturing policies. To overcome this problem of overcapacity, under pressure of the government the three entities consolidated in KAI in 1999 (Bitzinger 2019, 381–383).

The South Korean DIB has thus seen a gradual process of consolidation, the latest occurring in the shipbuilding sector. In 2019, Hanwha Aerospace, KAI, and LIG Nex1 (LG Group) were part of the top-100 arms producing enterprises worldwide. Beyond them, the most important defence enterprises are the HHI, Hyundai Motor Group, Hanwha Group, DSME, as well as their other subsidiaries. Poongsan, S&T Dynamics, Hanjin Heavy Industries, STX Offshore and Shipbuilding Corporation are further system-integrators (Bitzinger 2019, 381–382).

Table 27 - Market Share of the 10 biggest ROK Defence Enterprises in 2006 (Moon and Lee 2008, 131)

Rank	Company	Market Share	Rank	Company	Market Share
1	Samsung Techwin	11.9	6	LIG NEX 1	7.8
2	KAI	10.2	7	Doosan Infracore	7.3
3	Samsung Thales	8.5	8	Poongsan	5.9
4	Hanwha	8.2	9	Rotem	5.6
5	Hyundai Heavy Industries	8.0	10	STX Engine	3.6

In 2021, the Hanwha and Hyundai Holding Groups dominate the defence sector through their defence subsidiaries. The defence market has consistently been controlled by major firms, with the ten biggest contractors holding about 75% of the market share (Ann and Markusen 2003, 230; Moon and Lee 2006, 131; Moon and Paek 2008, 4; Jang, Song and Kim 2019, 10).

ROK defence industrial policy included the designation of defence enterprises that are crucial to sustaining the NDO as specialized suppliers, designating them sole suppliers of specific products. The system automatically led to technological path dependencies. Following the abolishment of the specialization system in 2009, these dependencies have weakened. The DIB has subsequently grown through the entrance of new suppliers.

Since the continuing designation system only includes contractors, but not always their suppliers, it does not capture the actual size of the DIB. Between 1991 and 2010, the number of designated defence enterprises fell due to financial stress from 84 to 75 in 2000, but it recovered to 93 by 2010 (Park and Yang 2014, 523). The growth of designated companies during the second decade was mostly due to the entry of SMEs into the sector (Jae-ok 2010, 200–201). After a peak in 2017 with 101 designated defence companies, their number has decreased to 88 in 2020 once again (DAPA 2020a). The number of direct subcontractors to these designated enterprises is estimated about 4000 companies (Jae-ok 2010, 200–201).

Depending on corporate organization, enterprises vary in their reliance on defence sales. Many companies do not publicize the ratio of defence sales in their overall performance. For example, in 2016 KAI conducted 66 percent of its sales in the defence sector, and both LIG Nex1 and Hanwha Systems all of their sales. For others it was only a small share, such as for DSME (12 percent), Hanwha Corporation (3 percent), and Hanwha Group (1 percent) (Bitzinger 2019, 385). Despite their dominance, larger system-integrators' average dependence on defence products is less than 10%, while SMEs have an average dependence of about 25%. The latter has also decreased since 2011, predominantly because of the entry of IT SMEs into defence (Jang, Min, and Ann 2015, 34).

Table 28 – Share of companies per dependency on defence (Jang, Min, and Ann 2015, 20)

	2008	2010	2012	2013
over 70%	35%	38%	38%	42.5%
50-70	10%	8%	8%	11.3%
30-50	9%	9%	11%	8.1%
under 30	46%	45%	43%	38.1%

Despite these low numbers, the ROK DIB is nearly cut in half by enterprises whose bulk of production depends on defence and those that not. This can be explained by the large number of subcontractors and SMEs in the sector (Jang, Song, and Kim 2019, 129). During the period of 2008 to 2013, the arms sales ratio stood at 8.1 percent for system integrators, 8.2 percent for

designated defence companies, and 17.8 percent for first tier suppliers (Jang, Min, and Ann 2015,19). For SMEs on the other hand, half of them received more than 50% of their income from arms sales (Jang, Min, and Ann 2015, 34).

Research Institutes

Civilian and defence R&D in South Korea has historically been separated both by geography and organization (Lee and Markusen 2003, 225). Limitations on defence-related R&D curtailed and disincentivized participation of universities and private institutes. In 1991, this systemic problem gained increased attention. Subsequent to the limitation of ADD's size and mandate in the 1980s, the participation of civilian and private actors in defence R&D had increased (Lee and Markusen 2003, 235–236). Since then, ADD has been at the central actor of collaboration between research institutes, universities, and think tanks (Weitz 2014, 49).

For defence R&D, the ROK defence industrial policy divides R&D into three broad fields: Individual basic research, projects for specialized research centres, and projects for technology transfers from abroad. While the first category is conducted by universities and private research institutes, the second category is facilitated by designated research institutes. This specifically includes core technologies that cannot be acquired from abroad. Until the 2006 reform, the bulk of defence research and systems development was primarily conducted by ADD. Since then, a gradual transfer of this task to defence enterprises has been implemented (Moon and Paek 2010, 5).

Since the reform, an incremental change in the organizational structure has altered ADD's role. The agency is limiting its focus to core technologies, while overall defence R&D is being outsourced to defence enterprises and research institutes. Nonetheless, ADD remains the key player in the field due to its expertise and advanced research facilities (Korkmaz and Rydqvist 2012, 75). It collaborates with industry, academia and private research institutes that conduct basic research, as well as R&D on core dual-use technologies (ADD 2021a). Following the Defence Reform 2.0 domestic defence industries will take over leadership of R&D programmes for weapon systems, while ADD is further focusing on projects that cannot be undertaken by private actors (Nam 2018, 2–3).

The agency is closely linked to AFROK and DAPA, as the Ministers of Defence, of Defence Acquisition, and the Chiefs of Staffs of the three service branches sit on its board. ADD houses five internal research institutes for specific technology fields, the Defence Science & Technology Academy, and three affiliated branch-specific institutes for the ground, maritime and aerospace domains (ADD 2021a). Each research institute has its own network of research

laboratories (Weitz 2014, 49). From 1998 to 2007, ADD also housed the Dual-Use Technology Centre, which then became ICMTC (ICMTC 2021). In 2014, the Defence Advanced Technology Research Institute was established under its roof. In the same year, the Institute of Civil-Military Technology Cooperation (ICMTC) and the Defence Industry Technology Centre were created as affiliated bodies (ADD 2021a).

In May 2021, the ADD board announced a further reorganization of the agency to advance the agency towards becoming a “first mover” of defence technology. It plans to consolidate its internal research institutes into three sub-organizations: The Missile Research Institute, the National Defence Advanced Science and Technology Institute, and the National Defence Testing Research Institute (ADD 2021b; Grevatt 2021c).

The interconnectedness of defence and civilian R&D in the ROK economy means that a separation between the two domains is hardly feasible. Major public and private research institutes are engaged in dual-use R&D and collaborate both with ADD and defence industrial enterprises. For example, KAIST (formerly the Korea Advanced Institute of Science and Technology and the Korea Institute of Advanced Studies) has established a joint research centre with Hanwha to develop AI technologies for defence in 2018 (Jun 2018).

The Korea Aerospace Research Institute (KARI), the civil aerospace and space agency of South Korea, likewise is engaged in dual-use R&D relevant for defence technology. During the 1990s, KARI and ADD had no coordination and often engaged in redundant research (Lee and Markusen 2003, 235). The agency has emerged as a leading developer of UAV technologies and is engaged in dual-use space projects (Park 2021).

The breadth of research institutes involved in defence R&D is displayed by them partaking in the annual Defence Expo Korea and their collaboration for defence R&D projects. These include government backed institutes such as the Korea Institute of Industrial Technology, the Korea Institute of Science and Technology (KIST), the Korea Institute of Science and Technology Information (KISTI), the Korea Institute for the Advancement of Technology, among others (DX Korea 2020).

5.3.4. Institutions

Ownership and Investment Regulations

Until 1998, ownership of defence industrial enterprises was controlled through the 1984 Foreign Investment and Foreign Capital Inducement Act. While liberalizing the access of foreign investors to the South Korean market, it restricted them from industries with relevance

for national security (Kausal and Markowski 2000, 3-53). Since 1998, the Foreign Investment Promotion Act and the in parallel amended Act on Special Measures for the Defence Industry regulate the change of ownership of as well as the investment in defence industrial enterprises (2017, Art. 6 (1); 2001, Art. 4 (3)).

The new legislation for the first time allowed foreign entities to invest up-to 100 percent in Korean firms, except where it threatens national security (MND 1999, 146). The changes were implemented to encourage technology and knowledge transfers, thereby strengthening the domestic industry. Nonetheless, changes in ownership of defence enterprises have to be approved by the Minister of Trade, Industry and Energy (Kausal and Markowski 2000, 3-53).

Following the promulgation of these Acts, a change in ownership, the investment in such enterprises, or a change in the corporate structure require prior approval from the minister of MOTIE, consulted by the minister of the MND. While the latter act specifically regulates designated defence enterprises and specialized research institutes, the former is also relevant for non-designated companies of the DIB. Under the Enforcement Decree of the Foreign Investment Promotion Act, foreign investors can also be barred from participating in the management of a defence enterprise (2017, Art. 7 (7)).

Defence Market Entry Regulations

Access to the South Korean defence market was primarily controlled through the 1973 Designation of Defence Materials and Industry Enterprises and the 1973 Specialization and Systematization System. It was implemented to prevent inefficiency and over-competition, allowing enterprises to focus on narrow technological fields. The system divided weapon systems into technological subsystems, further separated in specialized items (finished equipment) and systematized items (components and parts). Suppliers that produced these items were selected and permitted to participate in respective R&D with ADD or through international R&D collaboration.

In 1998, the Act on the Promotion of Technology Projects for Joint Civilian and Military Use was promulgated, permitting joint civil-military development projects and technological transfers. It was an essential step for bringing civilian enterprises into defence work.

Due to the obsolescence of barriers and monopolism, the system's overhaul was included in the National Defence Reform 2020. In 2009, the specialization system for selecting single contractors was finally abolished in favour of reducing entry barriers and increasing competition (MND 2011, 219; Jae-ok 2010, 198–200). Since then, the Defence Acquisition

Programme Act outlines the designations of “major” and “general” defence contractors according to technologies (2018, Art. 35 (2)). The designation depends on facility standards and security requirements and is conducted by MOTIE under consultation of DAPA. Thus, entry barriers to the defence market have considerably been reduced since 2009. Under the Act on Special Measures for the Defence Industry, the MND can on the other hand also force enterprises to produce defence products in times of crisis (2001, Art. 20).

Since the acquisition of defence products is solely handled by DAPA, the agency has considerable leverage in deciding on the market access of new companies. For foreign companies, this often requires consenting to offset trades, technology transfers, or R&D collaboration. In 2010, DAPA established an online system for gaining permissions for defence technology imports and exports, thus easing the process for civilian companies. The web portal unifies information and application processes for manufacturing, export, and import approvals (Shin 2010).

Intellectual Property Rights

Until 2006, the 1990 Patent Act regulated defence IPR. IPR rights gained through government funded R&D can be retained by the government, and traditionally the MND has applied this rule for defence R&D. ADD acts as the owner of such IPR. This specifically also includes knowledge gained through technology transfers and offsets. In special cases the MND has granted contractors licencing rights (Kausal and Markowski 2000, 3-44). The government can also prevent the filing of patents both domestically and abroad, if the knowledge is crucial for national defence (ROK Patent Act 2017, Art. 41). Defence patents may be classified, in which case the Korean Intellectual Property Office will not publish the patent (Art. 64).

The 2006 Defence Acquisition Programme Act, which established DAPA, transferred the MND’s authority over defence IPR to the organization. Where DAPA funds R&D costs for weapon systems and defined core technologies, these IPR rights are transferred to the government or ADD. DAPA may grant such licences to specialized research institutes and defence contractors (Defence Acquisition Programme Act 2018, Art. 31-2). Since an amendment of the enforcement decree in 2015, DAPA is also responsible for the creation of diffusion mechanisms for such knowledge (Enforcement Decree of the Defence Acquisition Programme Act 2018, Art. 36-2).

DAPA has thus worked towards easing their approach to incentivize new actors. Since 2015, it has acknowledged the IPR rights of universities and public research institutes in order to encourage their participation in defence R&D. This also includes the possibility of project

leadership by these actors (MND 2017, 115). The Defence Science and Technology Innovation Promotion Act, promulgated in 2021, upholds the retention of IPR by the government, but also eases joint private-public ownership and the transfer of rights to the research institutes by DAPA (2021, Art. 10; Enforcement Decree 2021, Art. 13). After the promulgation of the new act, DAPA announced to further revise its IPR policy, in order to boost the joint use of crucial defence IPR by domestic actors (Grevatt 2021b).

Arms and Technology Export Control

South Korea was a latecomer to the international arms export regime, with the first step towards controlling the export of strategic items being a bilateral agreement signed with the US in 1987. Based on the Foreign Trade Act, a presidential decree created a “import certificate/delivery verification” system that came operational in 1990. In 1992, the Foreign Trade Act was amended to implement an export permit system for strategic items controlled by the Ministry of Commerce (today MOTIE), which came into action in 1993. Between 1995 and 2001, South Korea became signatory to four major international control regimes, as displayed in Table 29.

In 2003, the Foreign Trade Act was further amended to create an online system (Yestrade) for the management of export control of dual-use and general defence industry materials. Major defence products and nuclear items are administrated through separate web portals. In 2007, the Foreign Trade Act was further amended to strengthen the export controls. The Public Notice on Trade of Strategic Goods and Technologies that lists controlled items has regularly been updated in accordance with the changes in international export regimes (Lee 2013, 3–8).

The South Korean export regime is based on four legal documents: The Foreign Trade Act, the Defence Acquisition Program Act, the Nuclear Safety Act, and the Act on the Control of the Manufacture, Export and Import of Specific Chemicals and Chemical Agents for the Prohibition of Chemical and Biological Weapons. Exports of controlled strategic goods need the permission of MOTIE, DAPA or the Nuclear Safety and Security Commission for such an export (Foreign Trade Act 2016, Art. 16 (2)).

For major defence items, Article 57 of the Defence Acquisition Program Act (2018) stipulates that the export of defence materials requires the permission of DAPA. Such major items are designated in accordance with the Act and are administrated by DAPA to ensure stable supply for domestic defence needs (Lee 2013, 8).

South Korea has also continuously strengthened its measures for defence technology retention, specifically since 2015. The 1994 Act on Special Measures for the Defence Industry delegates

the control of information to the MND. In 1998, the Act was amended with the explicit requirements for military agencies or government-invested research institutes to gain permission by the MND before sharing knowledge with enterprises or other agencies (2001, Art. 21-3 (3)).

Following these controls, the 2006 Defence Acquisition Programme Act stipulates a general requirement for a permission by MOTIE or DAPA before defence technologies can be exported (2018, Art. 57). The Act also places secrecy obligations on individuals involved in defence R&D (2018, Art. 50). In 2010 the article was amended, so that the sale of respective entities to foreign investors requires approval (Art. 50-2).

Table 29 – International Arms Export Regimes signed by South Korea

Year	Agreement	Target Area
1995	Nuclear Suppliers Group	nuclear proliferation
1996	Wassenaar Arrangement (original signatory)	conventional arms, dual-use goods and technologies
1996	Australia Group	biological and chemical weapons
2001	Missile Technology Control Regime	missile and missile technology proliferation
2017	Arms Trade Treaty (original signatory)	conventional arms

In 2016, a dedicated Defence Technology Security Act was promulgated, establishing a Defence Technology Security Committee as well as a respective Basic Plan. It authorizes DAPA to designate defence technologies and puts them under the export control regime. Involved entities need to devise security measures to prevent the leakage of such technologies. The act also introduces rewards for reporting of infringement and steep penalties for perpetrators. These strict new control measures are also reflected in the 2021 Defence Science and Technology Innovation Promotion Act, according to which infringing entities can be banned from defence R&D altogether (2021, Art. 9 (2)).

In 2020, the regime was further strengthened by an amendment that extended “situational licences” to conventional weapons. Before, these were only necessary for the fields of missiles and weapons of mass destruction (Hwang and Kim 2020). Such licences are necessary, if there is information that the recipient of items may intend to use them for weapons production.

5.3.5. Policy Portfolio: Linkage Policy

From the conception South Korean defence industrial policy in 1974, linkage policy has centred on putting public organizations at the centre of the R&D process. ADD, established in 1970, had a crucial role in conducting and driving indigenous R&D, and was thus from the beginning closely linked to defence contractors. Beyond the role of supplying R&D results to defence production, ADD was also tasked to deliver spin-off to civilian industries (MND 2009, 204; Bitzinger 2019, 383–384).

Since the late 1990s, the relevance of dual-use technologies and of spin-on complementing spin-off has been recognized. In 1998, the Act on the Promotion of Technology Projects for Joint Civilian and Military Use established the legal basis for joint civil-military development projects, technological transfers, standardization of specifications, and commercialization of results (2021, Art. 3). The act has continuously been amended since, extending and specifying the provisions on the implementation and funding of such projects. The Special Law on the Defence Industry was also amended in 1999, enabling extended collaboration of the MND with other ministries (KIDA 1998, 182).

Between 1994 and 2000, the MND designated five university-based research centres and government funded research institutes, establishing linkages in that direction (MND 2001, 159). Additional centres have been established since, bringing the total number to 35 in 2019 (DAPA 2020c, 102). Since 2008, the MND also utilizes Advanced Concept Technology Demonstrations (ACTD), mirroring the US approach. ACTD are utilized to identify technologies developed in the civilian sector early on and promote spin-on. For dual-use technologies, joint-ventures have been established by respective ministries and enterprises (Jae-ok 2010, 199). Through an amendment to the Act on the Promotion of Technology Projects for Joint Civilian and Military Use in 2007, ICMTC was established as dedicated organization in 2014 (2018, Art 12).

Beginning in 2000, ADD started to sign Memoranda of Understanding (MoU) in order to formalize its collaboration with other entities and promote civil-military cooperation. The approach became increasingly popular after 2010, when 27 MoUs had been signed. Until 2020 that number grew to 124. ADD primarily signs these MoUs with R&D actors such as universities, research institutes, other ministries, but also entities within the armed forces.

As displayed in Table 30, the agency's partners are evenly distributed among these actors. Through its affiliated body, the ICMTC, ADD also manages a considerably budget for the promotion of spin-off and spin-on, which is funded by 14 governmental agencies. The biggest

funders among these are DAPA (73%), MOTIE (20%), the MND (5%), the Korea Meteorological Administration (1%), and MSIT (1%).

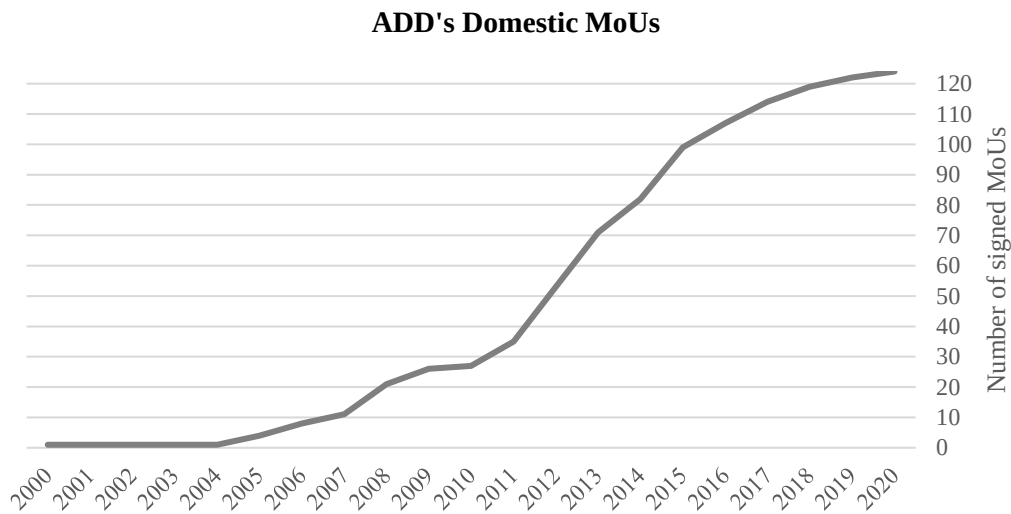


Figure 11 – ADD's domestic Memoranda of Understanding (ADD 2021a)

Table 30 – ADD's Domestic MoU Partners in 2020 (ADD 2021a)

MoU Partners	Total Number (Share of overall)
Universities	33 (27%)
Public Organizations	27 (22%)
Military	25 (20%)
Research Institutes	24 (19%)
Others	15 (12%)

Efforts to promote linkages within the DIB and with the civilian sector have spawned a number of organizations. These include the aforementioned Defence MICE Institute (2015; conventions and events), the Korean Institute of Defence Technology (research on linkage policy; industry-academia-research collaboration), the Korean Institute of Military Science and Technology (1997; annual conferences on dual-use potentials). Outlined in respective chapters above, the government has also strived for incentivizing civil-military linkages by easing IPR regulations and extended funding.

The establishment of defence clusters is a further step to harness the potential of local industries for defence production. In 2020, the MND announced the creation of further clusters in addition to five existing ones (Grevatt 2020b.) DPA organizations, such as DTAQ, have strived for extending their presence in these areas. Since 2003, the agency has created nine defence venture

centres in relevant localities to support SMEs and start-ups in entering the defence sector (DTAQ 2020, 20). Linkage policy also led to the creation of bi-annual defence expos. These are the aerospace focused Seoul ADEX since 2009 and the ground forces-oriented DX Korea since 2014. They provide a venue for boosting both domestic and foreign linkages.

Foreign Linkages and Collaboration

Historically, the US has been the ROK's most important partner. Starting in the 1970s, the ROK DIB began licensed production of US defence products and acquiring defence systems through both the US governmental Foreign Military Sales (FMS) programme and Direct Commercial Sales (DCS).

From simple firearms, licenced production gradually evolved and at the beginning of the 1990s involved complex weapon platforms such as ground systems, helicopters, and aircraft (Bitzinger 2019, 379). From 2002 onwards, Samsung was able to produce F-16 fighter jets, but the aerospace sector continued to have a high reliance on imported components until the 2010s (Moon and Paek 2010, 3–4). In 2008 South Korea's FMS status, and thus access to advanced platforms, was elevated on par to the NATO+3 group (MND 2009, 85).

The nurturing of a capable domestic industry has been a central goal for South Korean governments. Aside from supply reliance, it was also seen as a precondition enabling advanced foreign technology transfers and offsets (Bitzinger 2019, 283). The US's reluctance to share advanced technologies, and the restrictions imposed on South Korean defence exports by ITAR, were a further driver for the domestic production of components (Moon and Lee 2008, 133). The development of the domestic defence industry gradually allowed AFROK to shift to domestic suppliers from the 1990s onward (Bitzinger 2019, 379).

Central policy tool in South Korea's foreign interactions is its offset policy. It was first adopted in 1982 and became mandatory for all foreign defence purchases over a certain value in 1987. It distinguishes between technology transfers, exports, and equipment and tools. In 1992, the offset ratio was decreased from formerly 50 to at least 30 percent for contracts exceeding \$10 million. Originally implemented for employment and foreign exchange saving purposes, its purpose shifted to technology transfers and strengthening the domestic DIB in the after 1987. While in the 1980s only 25 percent of offsets were technology transfers, the ratio grew to 67 percent in the 1990s. With a share of 44 percent, ADD thus emerged as the major recipient of offsets, while the defence industry received a third of offsets (Han and Park 2004, 5–8).

Until 2006, a dedicated Offset Trade Committee oversaw the offset trade, afterwards an offset division within DAPA took over the task. DTAQ assessed the merit of proposed offset trade (DTAQ 2020, 18). During the 2010s, South Korea strived for easing its offset regulations in order to promote foreign contractors' participation in defence projects. It created an "offset banking system" that allowed foreign enterprises to collect offset credits, therefore foregoing the necessity for immediate offsets (Cho 2019). In 2019, the offset policy was replaced by an Industrial Cooperation Programme. The new programme places less importance on technology transfers, instead aiming to boost exports and introducing quotas for integrating domestic components in jointly developed systems (Song 2018; MND 2019, 141).

South Korean enterprises continue to engage in joint-development with foreign, especially US and European, defence companies (Bitzinger 2019, 382). In addition, the ROK has developed extensive ties with other nations to promote defence industrial cooperation. These ties are not limited to Western partners, but they include nations from all continents and with have rivalries between themselves.

Table 31 – South Korea's Agreements on International Defence Industry Cooperation (MND 2021, 337)

Period of Signature	Countries with Memoranda of Understanding
1991 - 2000	Thailand, Spain, UK, Philippines, Israel, Indonesia, Canada, Germany, Russia, Romania, Netherlands, Turkey, Venezuela
2001 - 2010	Vietnam, Australia, Bangladesh, India, Pakistan, Ukraine, Colombia, Egypt, Ecuador, Uzbekistan, Peru, UAE, Norway
2011 - 2020	Denmark, Poland, Chile, Czech Republic, Finland, Hungary, France, Botswana, Estonia, Croatia, Saudi Arabia, Kazakhstan, Argentina, Uzbekistan, New Zealand, Sweden, Paraguay
Countries with Agreements for International Technological Cooperation	
United States, France, UK, Israel, India, Indonesia, Singapore, Australia	
multilateral agreements (Australia, Belgium, Canada, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Denmark, UK, US)	

For example, the 43 nations that signed Memoranda of Understanding with the MND until 2020 include the US, Russia, and Venezuela. Closer agreements on technological cooperation exist with 21 advanced defence industrial nations such as the US, Israel, Singapore, and many NATO members. In addition to these cooperation agreements, the ROK has also signed agreements on quality assurance with 24 countries, and on the provision of price information with 4 countries (MND 2021, 337).

Additionally, ADD has signed cooperation agreements with 27 partner organizations in 13 countries, and established overseas offices in the US, Russia, Israel, and France.

Table 32 – ADD’s International Technology Cooperation Agreements (ADD 2021a)

Country	Number of Partners	Country	Number of Partners
US	12	India	1
Netherlands	3	Israel	1
Singapore	2	Norway	1
Australia	1	Russia	1
France	1	Sweden	1
GB	1	Thailand	1
Germany	1	<i>Total</i>	27

5.3.6. Networks

Agglomerations

The ROK defence industry has agglomerated both in the context of industrial policies, and general manufacturing and high-technology agglomeration trends. Defence agglomerations exist around the Gyeongnam and Chungnam provinces, and the Seoul Metropolitan area. In 1997, nearly 60 percent of defence enterprises were located in Gyeongnam, Busan, and Ulsan. More than 30 percent were located in the Seoul Metropolitan area, including Incheon and the surrounding Gyeonggi province. Chungnam, including Daejeon, was the home of more than 13 percent of defence enterprises (Lee and Markusen 2003, 231–232).

This agglomeration characteristic has largely remained through the assessment period, as geographical defence production data shows. In 2016, the Gyeongnam agglomeration, centred on Changwon, accounted for nearly 60 percent of defence production, the Seoul one for nearly 25 percent, and the Chungnam one for nearly 10 percent. Thus, more than 90 percent of defence production was located within these agglomerations. The Gyeongnam agglomeration has remained the centre of defence heavy industries and aerospace technologies, while the electronics industry developed in the Seoul cluster. The centre of the South Korean shipbuilding industry remains centred on Ulsan and Busan, with Daewoo, HHI, and DTAQ’s naval system centre being located there (Jang and Song 2019, 45).

Table 33 – Defence Industrial Agglomerations in South Korea 2016 (Jang and Song 2019, 45)

Province / City	Percent of Defence Production	Province / City	Percent of Defence Production
Changwon	27.3	Seoul	8.5
Gyeongnam	25.7	Busan and Ulsan	6.7
Gyeonggi/Incheon	15.3	Gyeongbuk and Daegu	1
Chungnam/Chungbuk	8.6	Daejeon	0.8

Clusters

Despite the strong agglomeration tendencies of the South Korean defence industry, there few specifically designed defence industrial clusters. Starting in 2020, the MND has declared its intention to establish and fund several defence clusters over the coming years (Grevatt 2020b). Local governments in Daejeon City, Nonsan City, Jinju/Sacheon, Gumi, and Yeongcheon have stated their intention to further promote the defence industry (Jang and Song 2019, 39). By 2021, there were five clusters with relevance for the DIS in Changwon, Sacheon/Jinju, Daejeon, Nonsan, and Gumi/Yeongcheon.

Within these agglomerations, the Changwon National Industrial Complex is especially important. Changwon sits at the centre of the Gyeongnam agglomeration, which has remained the centre of defence heavy industries and aerospace technologies. The city was selected for creating an industrial complex during the Park administration's defence industrial build-up in the 1970s. Thus, it emerged as the centre of South Korean defence production. At the beginning of the 1990s it produced more than 70 percent of the ROK's military equipment. Together with Busan and Ulsan, Changwon lies within the South-eastern Coastal Industrial Belt (Jang and Song 2019, 44; Markusen and Park 1993, 160–166).

In April 2020, DAPA announced the establishment of a pilot defence innovation cluster in Changwon. The cluster will receive initial funding of 45bn Won over 5 years, in order to foster the linkage between regional defence enterprises, research institutes, and universities (Grevatt 2020a). The projects include a Defence Materials & Components Lab with Changwon University, a support programme for defence materials and parts development with six enterprises, a defence SME venture business support site in Gyeongnam Technopark, and defence talent development and start-up support within the Changwon Convergence Centre (DAPA 2020b, 2).

The agglomeration of defence industries in Gyeongnam also includes the centre of aerospace industry in Sacheon and Jinju. In 2017, the Gyeongnam National Aerospace Industrial Complex was established in Sacheon and Jinju. It includes the bulk of Korean Aerospace Industries' production facilities in Sacheon, as well as over 60 related SMEs, and DTAQ's headquarters and aeronautical system centre in Jinju (BCI Aerospace 2019; Jang and Song 2019, 45). In 2015, the Korea Testing Laboratories moved their headquarters to Jinju. In 2021, the new Institute for the Promotion of Defence Industry and Technology, affiliated with DTAQ, was also established in Jinju (Kim 2021).

Daejeon, although not housing many production facilities, has become the most important defence science and research centre. More than 1600 high-technology companies, as well as 30 government-funded research institutes are located in the city. Most of them are within the Daedeok Innopolis (former Daedeok Science Town), which was established as a research cluster around KAIST in 1973. These include ADD's headquarters, ICMTC, DTAQ's precision missile and ammunition, one of its two defence reliability centres, and the Korea Aerospace Research Institute (KARI).

In 2018, a Defence National Industrial Complex was established in Nonsan, focusing on electronics and telecommunications equipment. The complex will profit from adjacent facilities of ADD, KAIST, and the armed forces, as well as the Korean National Defence Academy (Kim 2018). The objective of the local administration is to ultimately incentivize 160 out of the 400 relevant Korean enterprises to establish themselves there, with about 100 having plans to do so already (Lee 2020).

Gumi/Yeongcheon has not been declared a dedicated defence industry cluster, but it exhibits the features of one (Jang and Song 2019). Since 2016, the provincial government of Gyeongsang invests to elevate the area to national centre of defence ICT, attract Tier-2 suppliers, and maintenance facilities. Together with Gumi and Daegu, the Yeongcheon forms the industrial centre for C4ISR (command and control) systems. It also houses military facilities of the army and air force, as well the engineer corps and a military academy. Gumi has a strong presence of defence enterprises and the Smart Defence Technology Centre, while the DTAQ's C4ISR centre is located in Daegu (Jang and Song 2019, 45–46).

The Gumi Industrial Complex houses more than 260 defence enterprises and subcontractors, producing the bulk of guided weapons and ammunitions in Korea. Adjacent Gimcheon also has two major factories of LIG 1Nex, facilities of the Korea Testing Laboratories, as well as a future Combat System Testing and Certification Centre (Kim 2016; Ryu 2019). The city is also the

home of LIG Nex1's new facility specializing on the development and assembly of missiles (Dominguez and Cazalet 2021).

Civil-Military Partnerships

South Korea's emerging cluster policy is targeting the integration of both defence and civilian actors. Exemplary are the aforementioned clusters, where civilian-military partnerships are the core of their purpose.

Starting in 1994, the MND started establishing specialized research centres at universities and research institutes. These centres are responsible for basic research undertakings in specified technological fields. Until 2000, five such centres were established, two of them at Seoul National University (MND 1999, 142–143). The designation of such centres received new attention beginning in 2003, when five new centres were set-up. By 2014, 25 specialized research centres had been created and until 2019, the number grew to 35. Some of the projects have ended in the meanwhile and centres have been closed, but the further expansion of this policy approach is planned (DAPA 2014, 20; DAPA 2020c, 102).

5.3.7. Policy Portfolio: Financial Policy

South Korea's defence industry has benefited both from defence budgets that grew in parallel with the GDP, and the relative increase of defence R&D budgets. The MND's defence budget has traditionally been separated in force operating costs and the force improvement programme (FIP), recently renamed as force enhancement programme. The FIP budget comprises the budget costs for acquisition and R&D, thus being an important funding source for the South Korean DIB.

Although its share of the overall budget decreased from 40 percent in 1991 to 32 percent in 2021, it nearly sextupled in total terms, while the overall budget septupled. The 2015-2021 Mid-term Defence Plan outlines an increase of the force improvement budget back to 35 percent of the overall budget. In addition, as displayed in Figure 12, the overall defence budget is set-to further grow as well.

The defence R&D budget is a sub-budget of the of force improvement budget. While its growth has varied between years, between 1991 and 2021 the budget increased annually on average by 11 percent. Its growth specifically sped up after 2003 and 2017. Its increasing significance is also displayed by its ratio of the overall defence and FIP budgets. Starting from representing 3 percent of the overall and 7 percent of the FIP budget in 1991, it grew to respectively 4 and 13

percent in 2001, 7 and 21 percent in 2011, and finally 8 and 26 percent in 2021. In 2020 defence R&D represented 16,2 percent of the national R&D budget (Ann and Kim 2018, 74).

South Korean Defence and Force Improvement Budgets 1991 – 2025

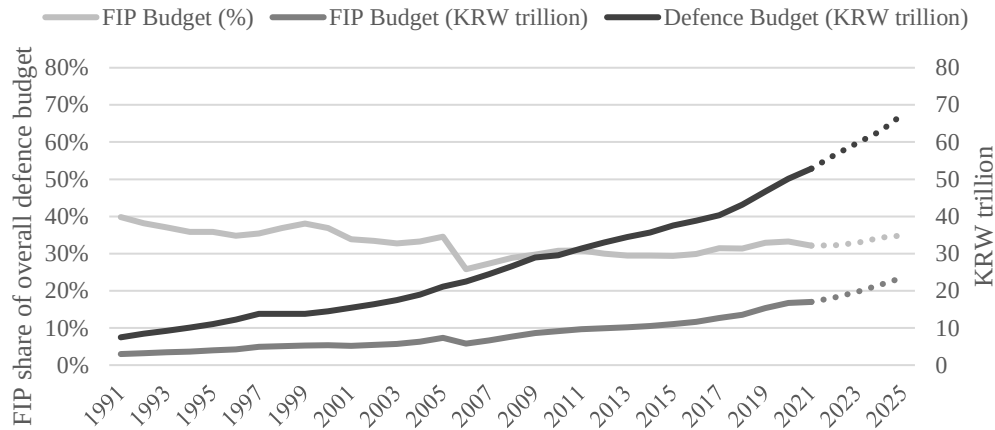


Figure 12 – South Korean Defence and FIP Budgets 1991 – 2025
(MND 2009, 359; MND 2011, 225; MND 2013, 222; MND 2015, 174; MND 2017, 127;
MND 2019, 159; MND 2021, 289)

South Korean Defence R&D Expenditure 1991 - 2021

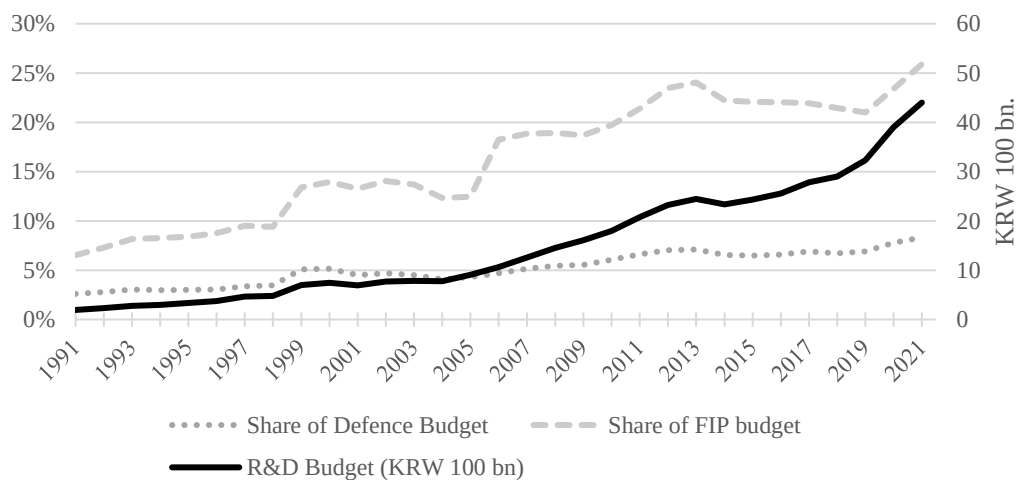


Figure 13 – South Korean MND Defence R&D Expenditure 1991 – 2021
(MND 1999, 289; MND 2003, 221; MND 2006, 260; MND 2009, 368; MND 2012, 248; Ann
and Kim 2018, 74)

The MND is planning to further increase its R&D expenditure to 15 percent of the overall budget in the meantime (MND 2017, 118). Private actors have also increased their R&D spending, specifically since more and more R&D undertakings are delegated to them, while ADD focuses on core technology undertakings. Due to the 2006 reform, private spending grew by 80 percent from KRW 132,2 bn in 2005 to KRW 239,9 bn in 2006 and tripled until 2008. Major defence enterprises spend around 10 percent of their budget on R&D (Moon and Paek

2010, 6). At the beginning of the 1990s, defence enterprises had only invested about 1,5 percent of their respective contract value into R&D (Moon 1991, 463).

The 1974 Special Law on the Promotion of the Defence Industry introduced a package of instruments for nurturing the defence industry (2001, Art. 7). These include reduced taxes and tariffs, low-interest loans, and legal and administrative support. While some mechanisms, like the National Defence Tax, were abolished in the 1990s, others such as the zero value-added tax were extended and new ones like the tax exemption on imported raw materials for defence purposes implemented (MND 1999, 146).

Until 2006, the South Korean government also employed the Defence Industrial Promotion Fund for nurturing the DIB. Originally founded as National Investment Fund to nurture heavy-chemical industries in 1974, it became the Defence Industrial Promotion Fund in 1980 (Moon and Lee 2008, 120). From 1980 to 2006 US\$ 550 million were invested through the fund, primarily supporting R&D, localization efforts, and sustaining idle factory capacities (Rim and Lee 2010, 15). Public financial institutions such as the Korea Development Bank and the Financial Services Commission have also invested in defence enterprises (Bitzinger 2019, 384).

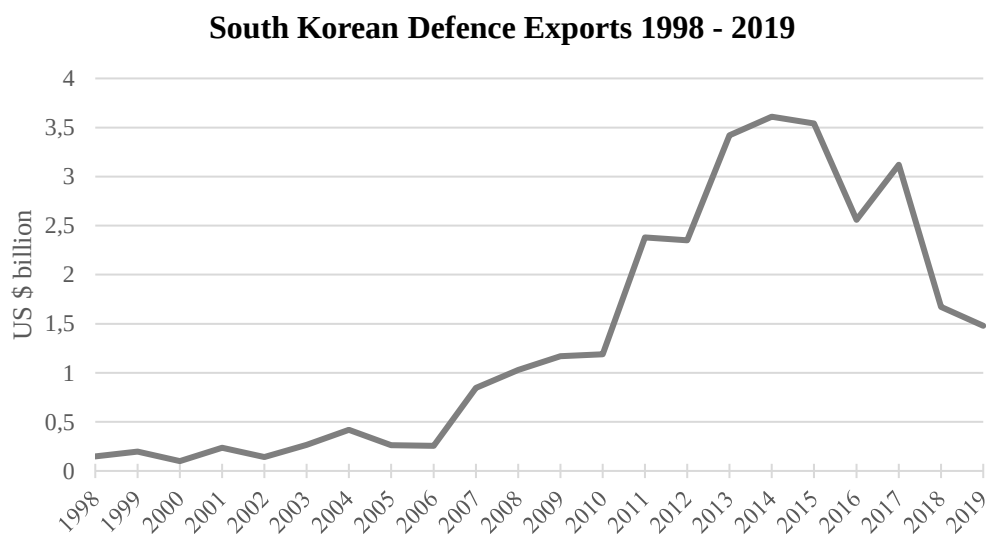


Figure 14 – South Korean Defence Exports 1998 – 2019
(MND 1999, 287; MND 2008, 212; MND 2018, 140; Grevatt 2020c)

Throughout the 1990s, the ROK defence industry nonetheless continuously suffered from deficits. Their budgets only recovered by 2002 (Moon and Lee 2008, 131–132). Exports have become an important finance source that alleviated the shortage. During the 1990s, South Korean defence exports were still limited to general equipment, small arms, and some smaller platforms. Both increasing sophistication and indigenization, and thus less restrictions by US ITAR controls, have enabled defence enterprises to sell increasingly advanced platforms abroad

(Bitzinger 2019, 386). Export promotion activities had already commenced in the late 1980s, both by the MND and defence enterprises themselves. Due to lacking competitiveness, financial prowess, and demand, it took nearly two decades until these efforts bore fruit (Moon 1991, 461).

From 2007 onwards, South Korean defence exports have rapidly increased and reached a record US\$ 3.6 billion in 2014. This means defence exports in 2014 were fourteen times those in 2006. The number of exporting enterprises increased from 47 in 2006 to 176 in 2016, and the number of buying countries from 47 to 89 (KDIA 2020, 4).

5.3.8. Policy Portfolio: Acquisition Policy

Like other policies, the central tenets of South Korea's defence acquisition policy were developed in the context of the Yulgok Project. Until the early 1990s, weapons production was primarily oriented towards imitating and importing technologies from abroad. Parallel to financial nurturing programmes and defence business designations, procurement methods paid little attention to transparency and competition. This approach became increasingly outdated with the demand for advanced cutting-edge technologies. Further driven by US reluctance to transfer knowledge on these technologies, the focus on indigenous development deepened (MND 2001, 152).

The restricted nature of ROK defence procurement was based on strict obligations on suppliers, including restrictive registration and information policies, as well as safety checks and investigations. Acquisition was conducted through sole-source, nominated, or open contracts. For major projects sole-source contracting was the dominant tool, and thus the bulk of acquisition value was handed out without competition. For domestic contracts, firm-fixed-contracts and cost-reimbursement contracts were preferred, for foreign procurement the first option dominated (Kausal and Markowski 2000, 3-41–3-42). Guided by the indigenization policy, ADD and selected suppliers operated without competition in delivering prototypes and implementing the subsequent production process (Bitzinger 1995, 241).

During the 1990s, acquisition of finished systems achieved a domestic procurement ratio of 77.5 percent (Moon and Paek 2010, 6). In 2008 the “Master Plan for Domestic Production” was created to further boost the domestic production of components and reduce the reliance on foreign supply lines (MND 2009, 213). Despite increasing localization ratios, in fact many sub-systems and components are still acquired from foreign sources (Bitzinger 2019, 388).

To sustain enterprises, long-term contracts and bail-out guarantees were employed. Contracts included advance payment clauses that often covered up-to 90 percent of the overall value

(Moon 1991, 449). Already since the mid-1980s, attempts were made to end excessive financial incentives and introduce competition (Moon 1991, 452). For example, in 1990 the National Defence Tax, financing the nurturing policy, was abolished (Moon 1991, 463).

In frame of the PPBEE system managing defence acquisition, the procurement source was chosen balancing between indigenization priorities and capability requirements. Options were the production using domestic R&D, domestic production utilizing foreign technology transfers (licencing), and foreign purchases utilizing either US Foreign Military Sales (FMS) or Direct Commercial Sales (DCS). Although priority was to be given to procurements that had the greatest potential for indigenization, spin-off, and long life-cycles, decision makers did not always follow these criteria (Choi 1998, 185–186). Contradicting policy priorities, the armed forces themselves often promoted foreign acquisitions due to cost, reliability, and delivery time concerns (Bitzinger 1995, 245).

Three interlinked concerns steered reform attempts in the last three decades: the competitiveness and indigenization of the defence industry, the efficiency and transparency of the procurement, and the fight against corruption.

Already before, an incremental process towards increasing competition had started. Designated defence items were slowly reclassified for competitive bidding. By 1990, this applied to about 8 percent of them (Moon 1991, 460). In 1996 the reform goal of extending competitive bidding, based on technical evaluations and life-cycle costs, to the bulk of acquisition projects was announced (Choi 1998, 209). Nonetheless for some areas restrictive selections were deliberately retained, such as that KAI remained the preferred contractor for aerospace projects (Kausal and Markowski 2000, 3-41). Until 1999, 40 percent of items produced by first-tier and 60 percent of items produced by second tier-companies had been opened to competition (MND 1999, 145).

Driven by pressures on the budget in wake of the 1997 financial crisis, time evaluation, project management tools, life-cycle and information management gained importance in procurement. Open competition was to be extended to all acquisition and R&D projects, save those for sophisticated platforms and core technology projects managed by ADD. Thus, all firms with the technological proficiency required should be able to participate in defence projects. As outlined above, a legal framework for dual-use technology utilization and the harmonization of standards was also drawn-up to this end (MND 1999, 142–147).

Additionally, the promotion of SMEs in defence emerged as policy goal, with the MND setting the objective of delegating 20 to 30 percent of contracts to them (Kausal and Markowski 2000,

3-44). To that end SMEs were classified in first-tier and second-tier companies, with associated items and technology fields. About a quarter of the items provided by second-tier companies were reserved for SMEs only (MND 1999, 145).

Foreign procurement was also limited to items that were either decisively more cost-effective or that the domestic DIB was yet unable to produce (MND 1999, 147). Sources had already diversified before, as enterprises from Western Europe, Israel, and Brazil had substituted some US contractors (Moon 1991, 461). The aforementioned budget concerns after 1997 meant that foreign sourced FIPs were postponed and domestic acquisition re-prioritized. The import of weapons was to be completely steered by competition, based on a systems of evaluation standards that would guide access to competitive bidding (MND 2003, 140).

Despite all the efforts, competitive contracts primarily remained restricted to small items produced by SMEs and foreign contractors. Promoting competitive bidding as procurement tool remained a policy goal throughout the 2000s. An important step was the abolishment of the Specialization and Systematization System following DAPA's founding in 2006 (MND 2011, 219).

Until 2016, a uni-resource, multi-supplier system was implemented to ensure competition and the resilience of supplies. These specifically also aimed at civilian companies, whose participation is facilitated through the Defence Venture Centres (MND 2017, 119–120). As further incentives, liability clauses were limited by a 10 percent of contract value ceiling and a “fidelity recognition system” further limits liability is research was conducted in good faith (MND 2017, 123–124).

Competitive bidding based on price has become the main tool for DAPA's acquisitions. Foreign contractors also remained obligated by the offset policy and its subsequent pendant. Nonetheless, the agency still utilizes nominated and limited contracts for major acquisitions, and entry barriers for non-traditional suppliers remain high (DAPA 2021; MND 2019, 139). Bitzinger argues that ROK procurement is, in contrast to official statements, still dominated by non-competitive and sole-source contracts (2019, 382). Current efforts aim at the adoption of a fast-track purchase and an “evolutionary” acquisition system, offering different contract options for respective development phases. The latter is based on incremental and spiral development approaches, taking into account new technologies and interim evaluations (MND 2019, 136).

DAPA has also strived to strengthen project management capacities and by 2018 a project management office (PMO) system had been created, which is tasked to accumulate expertise for specific technology fields. DAPA in general is in the process of being redesigned towards

a project management-focused structure. Furthermore, it has shifted towards a “pursuit-type” approach, thus contracting out the development of technologies for weapon systems with pre-determined capability requirements (MND 2019, 135–136).

Intertwined with the strive for more competition has been the issue of transparency. In 1993, auditing and inspections were implemented to counter abuses (Choi 1998, 178–189). Further transparency clauses followed in 1996, and a new information policy outlining the acquisition plan for the next five years was made available for both domestic and foreign contractors (Kausal and Markowski 2000, 3-41–3-43).

In the early 2000s the PPBEE system was streamlined and simplified, and additional government agencies included into an “open decision-making system” (MND 2003, 135–137). Tools such as the Defence Information Technical Architecture (DITA) created in 2007 aimed at further increasing procurement efficiency (MND 2009, 221). Information management systems, such as on cost and risk management, were developed to prevent illegal undertakings and boost information exchange with the industry (MND 2011, 217–218).

The fight against corruption and networking between the defence establishment and industry has become a core topic of reforms in the 2010s. Measures include disadvantages during bidding and the designation as “unscrupulous vendor”, limiting or banning the access to bidding (MND 2013, 230). In 2014, the reward system for reporting corruption was extended (MND 2015, 182). Until 2018 supervision and penalty mechanisms were further extended to include intermediary actors and trading agencies, and monitoring and supervision systems were created for both ADD and DTAQ (MND 2019, 131).

5.3.9. Policy Portfolio: Human Resource Policy

Employment of the South Korean DIB has continuously grown throughout the assessment period. From roughly 19 000 employees in 1991, the work force increased by a quarter until 2002, and nearly doubled until 2017. This is in line with the MND’s 2008 declaration to develop the defence industry into a new economic growth engine (MND 2009, 211).

The growth of the defence industry was driven both by domestic arms sales and arms exports (Jang, Min, and Ann 2015, 26). Indicative for the whole assessment period, between 2008 and 2013 the bulk of the work force was employed by the top 50 defence companies, with roughly half of personnel working in production and a quarter in R&D, and 35% being employed by SMEs (Jang, Min, Ann 2015, 8–27).

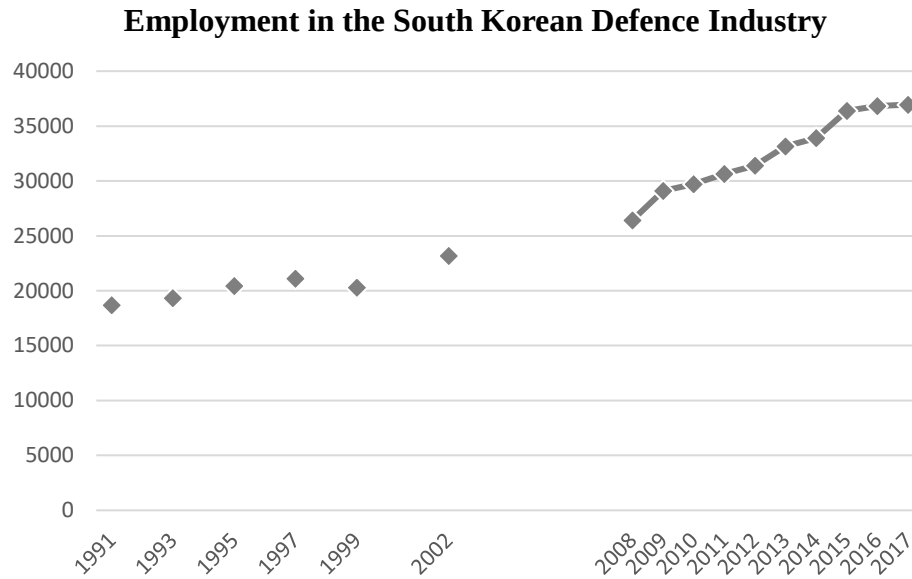


Figure 15 – Employment in the South Korean Defence Industry
(Bae 2003, 78; Han and Park 2004, 10; Jang, Min, and Ann 2015, 26; Ann and Kim 2018, 9; Jang, Song, and Kim 2019, 6)

Talent Recruitment

Since South Korea relies on a private defence sector, talent recruitment is conducted by enterprises themselves. For internal demand, the MND recruits technical experts directly from universities (MND 2011, 262). Additionally, the MND deepened collaboration with civilian universities and research institutes, and increased programmes to send service members abroad to study foreign defence industries (MND 2007, 139–146). Due to South Korea having conscription for all male citizens, the MND is also able to recruit personnel when completing their military service. As ADD narrows its focus on essential core technologies, defence enterprises that increase their defence R&D undertakings are also recruiting former ADD researchers (Korkmaz and Rydqvist 2012, 75).

Public DPA organizations also offer additional training for personnel from both government bodies and defence enterprises. South Korea has its own defence acquisition education system, which since the 2006 reform has been managed by the Korea National Defence University and DAPA. The university has an Occupational Work Training Centre and a Graduate School of Defence Management, with courses on the areas of procurement, project management, and in other related fields. DAPA on the other hand has an Education Centre that offers courses for government, armed forces, and defence industry employees. It collaborates with universities, research institutes, and other organizations in creating training courses on defence acquisition issues (DAPA 2021).

In 2018, the MND announced the merger of Korea National Defence University's Occupational Work Training Centre and DAPA's Education Centre. The two centres will be merged into one specialized organization under DAPA control, with the intention of centralizing training of personnel in one body (MND 2019, 135).

Since at least 2014, personnel exchanges between DAPA and the military branches in the area of acquisition were facilitated, as well as a dedicated career path system created (MND 2015, 183). Focusing on science and technology itself, ADD offers professional and specialized training for R&D specialists from both the public and private sectors (ADD 2021a). DTAQ offers training on export related issues (DTAQ 2020, 28). The ministry also implements extended training for civilian employees on defence issues, among else weapon systems and acquisition issues (MND 2021, 128–129).

The National Defence Reform 2020 of 2005 introduced the civilianization of the workforce, which has shaped the MND's human resource policy since. The reasoning for this civilianization is the aim to increase civilian oversight and democratic control over the military (Han 2006, 121). It entails the recruitment of civil experts to supplement and replace the officer cadre. Within the extent of the military, the plan outlined an increase from 3.9 to 6 percent in 15 years, primarily affecting positions within the MND itself. This civilianization specifically also targeted DAPA, but it has long remained limited to its leadership. In line with the protracted implementation of the overall reform, the general civilization of DAPA lagged (Watanabe 2014, 4).

Since 2017, the civilianization of the MND and its subordinate organizations has taken up speed again. This has also affected leadership positions within the MND and KNDU (MND 2021, 128–129). The 2016 Defence White Paper outlined the goal of reducing the ratio of DAPA's military personnel from 50 to 30 percent (MND 2017, 124).

5.3.10. Summary

Of the three compared defence innovation systems, South Korea's stands out due to the lowest number of systemic failures and the highest level of foreign collaboration. The ROK's defence industrial development during the assessment period was the continuation of previous efforts for an indigenous defence industrial build-up since the 1970s. Throughout the thirty years it has evolved driven by the two poles of financial constraints and threatening actions of North Korea. While overarching reforms for the armed forces stalled continuously, the DIS has undergone a considerable and successful overhaul.

Until 2021, the country has introduced a broad number of planning tools for managing and steering different areas of the DIS. These tools are regularly updated and integrated with national S&T and R&D planning. Since 2008, the defence industry has been declared an economic growth engine and received increased attention in macro-economic planning.

During the 1990s, the DPA organizational structure was characterized by a high level of decentralization. Eight organizations were merged into the Defence Acquisition Programme Administration in 2006. Although the partially civilianized DAPA lost some of its overarching authorities in 2014, such as requirement determination and planning, it still represents the most potent entity in the South Korean DIS. With DTAQ an additional organization for quality inspections and defence S&T planning exists since 1981. Further organizations for various aspects of linkage policy and technology transfers have been created during the 2000s and 2010s. Most of them are also engaged in export promotion in their respective fields.

The ROK defence industry has continuously been in private hands, with major firms being controlled by chaebols. In line with market opportunities, some firms have merged or exited the defence market during the assessment period. The public hand has invested in some enterprises, especially where monopolies exist, such as in the aerospace industry. Actors are divided in half between those predominantly relying on the defence market and those relying on the civilian market. With the abolishment of the specialization system for selected suppliers, the market has de facto been opened to all industries.

Defence R&D has historically been dominated by the ADD, a public actor incorporating features of an organization. Since the late 1980s and increasingly the early 2000s, ADD has been limited to crucial technologies. The bulk of defence R&D has since been outsourced to private enterprises and institutes, with ADD taking a central role as enabler.

The industry has agglomerated in line with industrial policy directives of the 1970s, but since broadened and integrated with high-technology sectors located primarily around Seoul. Aerospace, armament, and shipbuilding industries remain anchored in the South. Five clusters have developed as consequence of industrial policy and local government initiative. Additional clusters are envisioned by the MND. Already since 1994, the MND has established civilian-military partnerships and created designated defence research centres at universities and research institutes.

The respective ROK policy portfolio has been adapted and calibrated throughout the assessment period. Linkage policy: Furthering both domestic and foreign linkages has eventually been the most crucial element. Commanding over already sufficient linkages in 1991, specifically due

to ADD's engagement in the R&D process, additional steps were undertaken subsequently. In 1998, a legal base for civilian-defence joint undertakings was created, and in 1999 for collaboration between public organizations. The aforementioned designated research centres and clusters furthered this effort. ADD has also continued to formalize collaborations with various research entities throughout the economy through MoUs.

The MND utilizes specific tools for civilian technology sourcing already since 2008, and a dedicated organization for that purpose was created in 2014. This ICMTC also commands over a considerable budget for boosting spin-off and spin-on, funded by both civilian and defence organizations. Foreign linkages have likewise been expanded. The 1990s policy focus on licenced production and technology transfers through offsets has gradually evolved towards an industrial collaboration programme and local content mandates. With 21 technology collaboration agreements and 43 MoU, South Korea's international collaboration network exceeds geographical and political divisions. In addition, ADD directly cooperates with 27 foreign research entities.

Financial policy: The defence sector has profited from continually rising defence budgets. Force improvement and specifically R&D budgets have increased both in absolute and relative terms, especially accelerating since the early 2000s. Some nurturing instruments are retained, such as decreased taxes and tariffs, while others such as a special promotion fund were out-phased. The increased sophistication of the industry has established South Korea as a major defence exporter, with enterprises benefiting from growing sales abroad as well.

Acquisition policy: Defence acquisition has predominantly relied on sole-source and nominated contracts during the 1990s, employing firm-fixed and cost-reimbursement contracts. ADD and its selected industrial partners operated without competition in defence R&D. In addition, long-term contracts, bail-out guarantees and generous advance payment clauses inhibited competition. Starting in the late 1980s, competition was gradually implemented through the reclassification of items. Its extension to the bulk of acquisition undertakings, except for major ones, was only achieved in the 2000s and 2010s. In the late 2010s, policy attention moved to increasing incentives and reducing risks, as well as establishing new supplier and acquisition management systems, project management, and research steering approaches.

Transparency efforts through auditing and inspections have been implemented since 1993. Driven by the financial crisis of 1997, evaluations, transparency, and life-cycle costs gained increased attention. Further foci were the increased support of SMEs and indigenization. The acquisition system was streamlined in the early 2000s, increasing the efficiency of the process

and transparency through involving other ministries. Additional information mechanisms, penalties and report rewards have been introduced as well.

Human resource policy: Due to the designation of the defence sector as an economic growth engine, it has received increased attention for its overall economic role. Between 1991 and 2021, the workforce indeed doubled. While private enterprises recruit personnel themselves, they have profited from ADD's narrowed mandate, as many researchers have transferred to them. They also benefit from a comprehensive defence acquisition education system provided by DAPA and other organizations.

Recruitment for organizations is conducted directly at universities or in the frame of conscription. A dedicated career path has been established for the field. In an effort to civilianize defence and increase democratic oversight, civilianization efforts have been promoted since 2006. The endeavour received new attention after 2017, with the current goal being to establishment of DAPA as predominantly civilian organization.

The institutional framework has evolved in parallel with changing policy foci. The sector had been in private hands since its emergence, with foreign investments being barred until 1998. Access was liberalized in 1998, with MOTIE overseeing any changes in ownership or corporate structure, and investments. It may still ban foreign investments, if national security is threatened. In order to open the sector and harness the capability of civilian industries, in 2009 the specialization system was abolished and hence market entry liberalized.

Until 2006, for any government funded R&D and foreign technology transfers enabled by offsets, IPR were transferred to ADD. The filing of patents can be prevented or classified under national security concerns. Since 2006, DAPA has gained central authority for these decisions and related licencing activities. In 2015, DAPA also received the specific tasks to promote domestic technology diffusion. IPR rights of research actors, especially civilian ones, are increasingly recognized. With the new S&T innovation promotion act in 2021, additional joint-ownership and transfer possibilities were introduced. DAPA plans a further revision of the respective regulations.

South Korea initially introduced its first arms export controls due to pressure of the United States. This was formalized through a bilateral treaty in 1987 and the subsequent introduction of an import certificate/delivery verification system in 1990. In 1993 an export control system was created, which has been continuously strengthened since. Subsequently, the country signed all major international arms treaties. This system is managed respectively by MOTIE, DAPA, and the Nuclear Safety and Security Commission.

Retention efforts in the form of a technology export control were implemented shortly after the arms export system in 1994, and consecutively expanded in 1998 and 2006. Secrecy obligations for research actors were likewise introduced in 2006, and an approval process for the sale of such entities in 2010. Efforts in this scope led to the promulgation of the Defence Technology Security Act in 2016, including a respective committee and basic plans. DAPA has gained the authority to designate respective technologies and created additional obligations and penalties for actors. In 2020, “situational licences”, addressing the utilization by recipients, were extended to conventional weapons as well.

South Korea has clearly undergone the shift from classic to transitional defence sector during the assessment period. In 2021, the civilian and defence sectors have established strong links and been partially integrated. In its DPA reform, the country has followed international trends of horizontal and vertical integration. Putting a special focus on linkages, a number of dedicated organizations have been established as well. Although lacking any notable systemic failures, the policy portfolio has continuously been expanded and deepened. Thus, there is a good argument that it has achieved the step to the fourth generation of innovation policies.

This is signified by the integration of defence industrial policy into macro-economic planning, establishing the sector as one of heightened importance. Public funding for R&D can hardly be separated between defence and civilian purposes, with the promotion of bi-directional technology transfers being a central policy element.

The ROK DIS has continued the process of a gradual increase in sophistication during the assessment period, transiting from licenced production to becoming a major arms exporter of advanced systems. This also opened new funding and de facto unlimited collaboration opportunities, with countries all over the globe. While not achieving the status of net arms exporter, the South Korean defence sector has managed to rise from the reliance on technology imports in the 1990s to being on par with international leaders in 2021.

6. Analytical Comparison

6.1. Policy Portfolio: Overarching Tenets and Planning Instruments

To provide a conclusive overview of differences and similarities of the defence innovation systems in the three nations, the subsequent summary provides a simplified comparison of the analytical framework. Comprehensive comparison tables are provided in the appendix.

Table 34 – Comparison: Overarching Tenets and Planning Instruments

Policy Portfolio: Overarching Tenets and Planning Instruments				
	Overarching Tenets	Planning Instruments		
		<i>Main Planning Cycle</i>	<i>Timeframes</i>	<i>Continuity</i>
China	techno-nationalism indigenization / absorption / reliance on domestic suppliers	5-years	1-, 5-, 10-, 15-, 10-20- years	established
Japan			1-, 5-, 10-years	not yet established, irregular updates
South Korea			1-, 5-, 15- year	established

When it comes to overarching policies, all three countries follow in its core the same approach of techno-nationalism, promoting self-sufficient capability and supply reliance. This entails a strong role of the government in the DIB management, the promotion of indigenization and strategic independence, and is linked to public nurturing policies. The details of these overarching policies are nonetheless rooted in domestic systemic problems and military demands, they are thus diverse.

The reform undertakings of the last three decades have mitigated some of the differences, notably the integration of civilian and defence sectors, and the unified push for the utilization of dual-use technologies. In a broader view, the reform drive has originated in all three countries from increasing threat perceptions, new demands on national defence, and the demand for civilian high technologies, as well as the incapability of the classical defence sector to do fulfil the latter.

Mechanisms and policy tools employed to pursue these policy goals vary likewise. The planning instruments utilized centre on a five-year planning cycle. Of these, China has developed the most extensive planning panoply. All three nations utilize 1- and 5-year strategies, but there are differences in the time horizon of long-term plans. Although all three have

revamped and extended their portfolios, in China and South Korea concise planning cycles have been established, while Japan has not yet fully established continuous cycles.

Dedicated plans for reform issues, such as the basic plans in South Korea and the reform of the DIB in Japan, have been created, as well as focused plans for specific industrial life cycle stages such as R&T. In all three nations the increased comprehensiveness of planning portfolios hence displays the introduction of advanced innovation policy concepts.

6.2. Organizations

Table 35 – Comparison: Defence Organizations

Defence Organizations								
	Trend 1991 – 2021	Additional Organizations	Separation of Tasks			Relation to the Armed Forces		
			1991	2021		1991	2021	
China	horizontal and vertical integration	linkage, IPR	fragmented DPA structure	defence requirement planning by armed forces	separate bodies for defence S&T, R&D	within the armed forces	PLA internal	
Japan		-			single organization		sub-ordinate to armed forces, partially civilianized	
South Korea		linkage, quality, SME support						

The reform of defence procurement agencies has followed along the same lines in all three cases. This was the integration along horizontal and vertical hierarchical lines, culminating in centralized organizations with considerable authority. Both Japan and South Korea have established a single DPA, while China has a duopoly roughly separated between R&D and S&T mandates.

All three relied on fragmented DPA structures in 1991, but they integrated them in consecutive steps until 2021. While requirement planning remains with the armed forces, both Japan and South Korea have established separate civilianized organizations. In China, the DPA remains within the Central Military Commission, hence having a clear military character. Considering this, in China the organization structure is thus still guided by classical concepts. Nonetheless, like in Japan and South Korea, Chinese DPA organizations have also increasingly been reformed into enablers and network nodes.

Both China and South Korea have created additional organizations to promote linkages, IPR diffusion and CMI/MCF policies in China, and quality control and SME support in South Korea.

Although there have been discussions in Japan to include civilian organizations into defence R&D promotion, none have to date been established or integrated. This can be explained by a much higher level of cross-sectoral integration and established linkages in Japan, where such dedicated organizations are not needed for boosting civilian-defence integration.

Although the involvement of civilian organizations in the defence sector is more extensive than displayed in Table 36, in the two crucial fields of defence industrial policy making and funding overarching similarities exist. In 1991, Chinese defence industrial policy drafting was still handled by COSTIND, an organization within the armed forces. Since its civilianization as SASTIND in 2008 and the creation of an MIIT department for CMI promotion, industrial policy making relies with the respective Ministries of Industry and S&T in all three countries. This clearly shows advanced innovation policy management, where industrial policy is conceptualized as overarching rather than sector specific.

Table 36 – Comparison: Civilian Organizations

Civilian Organizations				
	Defence Industrial Policy		S&T / R&D funding	
	1991	2021	1991 – 2021	
China	none	Ministries of Industry	Ministries of Industry	Ministry of Education
Japan	Ministries of Industry		Ministries of S&T*	-
South Korea				Ministry of Economy and Finance

* In Japan, the Japan Science and Technology Agency (JST) acts as funding agency, while the Ministry of Education, Culture, Sports, Science and Technology (MEXT) acts is responsible for planning.

These ministries also play a central role in funding defence R&D and S&T, complemented by other public organizations. In China, the Ministry of Education is noteworthy due to its funding for defence universities and defence research centres at universities. In South Korea, the Ministry of Economy and Finance has also directly funded defence and dual-use undertakings. R&D funding is likewise increasingly handled as an overarching issue, although separation continue do exist in China and South Korea. Japan is exemplary, as defence R&D funding is very limited and dual-use funding dominant.

6.3. Actors

Table 37 – Comparison: Actors

Actors						
	Classic Defence Actors					Civilian Actors
	<i>Market Structure</i>	<i>Ownership</i>		<i>Main research actors</i>		<i>Crucial Opening Reforms</i>
	1991 – 2021	1991	2021	1991	2021	1991 – 2021
China	monopolistic	within ministries	state-owned	state	state / state-owned	CMI (2004), MCF (2016)
Japan	monopolistic / duopolistic	private		private	private	no separation
South Korea				state (ADD)	ADD + private	Dual-use Act (1998) end of designation system (2009)

There is clear difference between the DIBs of China on one side, and of South Korea and Japan on the other. While the former retains state-ownership of classical defence enterprises, the latter two nations have continuously relied on privatized industries. This is reflected in the market structure, where the classical defence sector has clear monopolies in China, and monopolies and duopolies in Japan and South Korea. Nonetheless in all three countries the market structure is the result of deliberate nurturing policies. Although the latter two countries' defence markets have gravitated away from entrenched monopolies and duopolies, in 2021 it was still the most applicable characterization.

Major defence enterprises in all countries are also engaged in the civilian market, both directly and through subsidiaries. For China the extent of this involvement is unknown, but important. In Japan major defence enterprises predominantly rely on the civilian market, while SMEs are often fully dependent on defence work. In South Korea, the DIB is split between enterprises primarily relying on defence and civilian commercial activities.

When it comes to the main defence R&D actors, the picture changes. In 1991, only Japan relied on private entities. In South Korea ADD guided private entities and thus presented the crucial actor in defence R&D. Its narrowing focus on crucial defence technologies has increased the relevance of private R&D actors. In China, defence R&D was, like defence production, located

within the government itself. With the formation of the DIEGs in 1999, the bulk of defence R&D is now conducted by state-owned enterprises and public research institutes.

With respect to the three elements of market structure, ownership, and research actors, the separation between China, and Japan and South Korea is evident. The government takes a much greater role within the Chinese DIS, both through owning classical defence enterprises and main research actors. Nonetheless, the DIEG reforms have decreased direct influence and increased independence throughout the assessment period. The public role hence remains between enabler and provider, while in Japan and South Korea governments have clearly reimagined the public role as enabler of the DIS.

The integration of the defence sector with the civilian sector, specifically high-technology industries, has been a major issue during the assessment period. All three nations have attempted to utilize civilian high technology for defence spin-on since the late 1990s, with increasing attention given to integrating civilian enterprises, research institutes, and universities in defence R&D.

In Japan respective reforms were not necessary, as access was already managed through acquisition policies. Efforts to integrate universities in defence R&D have so far stalled. Both China and South Korea have opened their defence sectors. Until 2021, barriers to defence R&D and acquisition have largely been broken down for civilian enterprises. Dedicated organizations, such as CMI and MCF departments, as well as DAPA and DTAQ, have been asked to boost integration efforts. All three DIS have therefore entered a state of transitional defence sectors.

6.4. Institutions

Table 38 – Comparison: Ownership and Investment, and Defence Market Entry Regulations

Institutions – Ownership and Investment Regulations						
	<i>Domestic Investment</i>		<i>Foreign Investment</i>		<i>Defence Market Entry</i>	
	1991	2021	1991	2021	1991	2021
China	banned	allowed, regulated	banned	regulated	closed	open / management through acquisition policy
Japan	allowed, regulated		regulated		management through acquisition policy	
South Korea	regulated		banned		designation system	

Due to the overarching approach of techno-nationalism, guided by a strong public hand in all three compared countries, investments into the classical defence sector have been a contentious

issue. While both Japan and South Korea have permitted domestic investments throughout the assessment period, these have been closely regulated. Following the demand for additional funding sources, China allows private investments since the late 2000s. Thus, in 2021 all three countries permit, but regulate, domestic investments.

Foreign investments in the defence sector have been even more contentious, with only Japan allowing them in 1991. South Korea permits such investments since 1998, while China liberalized its policy in 2020. While all three nations hence allowed foreign investments in 2021, these are strictly regulated under national security considerations and limited by thresholds. It also remains unclear, how the newly created Chinese regulatory regime will be implemented. Ownership itself follows the lines identified in the preceding sub-chapter. While defence enterprises in Japan and South Korea are in private hands, China permits the involvement of civilian enterprises, but the classical defence industry is owned by the state.

The trade-off between liberalization and classification is signified by these respective reforms. While liberalization has taken place to enable technology transfers and open-up new sources of investment, classification regulations to prevent unwanted technology outflow or threaten control of defence industries have been retained. In the case of Japan, these have in fact been strengthened for foreign investments. All three governments follow very similar approaches to manage this trade-off.

Market entry to the defence market is likewise a delicate issue of defence policy. None of the compared countries permitted open access to it in 1991. In China, defence R&D and production were solely handled by state-owned enterprises. Only chosen private ICT companies, with close relations to the PLA, were allowed to fill capability gaps. In South Korea, the designation and specialization system likewise closed the sector to enterprises without such licences. In Japan, a similar approach was implemented through acquisition policy in the frame of Kokusanka projects.

By 2021, the demand for civilian high technology had led all three governments to liberalize market access. South Korea abandoned its specialization system in 2009 and China has opened the market to private R&D undertakings in the early 2010s. Market entry is now de facto managed through acquisition policy in all three countries, but there are no legal hurdles for domestic enterprises to participate in defence tenders, unless they have specifically been banned to do so. Market entry regulations thus mirror the necessary liberalization to enable integration of the transitional defence sector and entice NTBFs for defence work.

Table 39 – Comparison: IPR Regulations

Institutions – IPR							
	<i>Dedicated Defence IPR Law</i>		<i>Government-funded IPR</i>		<i>Organization for Defence IPR Diffusion</i>		<i>IPR Classification Provisions</i>
	1991	2021	1991	2021	1991	2021	1991 – 2021
China	yes		retained	retained	no	yes	yes
Japan	no			transfer or joint ownership			
South Korea							

When it comes to defence IPR regulations, there are major overlaps between the three countries. In 1991, all three governments retained the IPR of publicly funded defence research. To increase incentives, both Japan and South Korea have liberalized these provisions and created the options of IPR transfer and joint ownership, when R&D is conducted collaboratively. For China there is no information available, leading to assumption that IPR is still retained. Nonetheless the bulk of defence R&D is conducted by state or state-owned entities anyhow.

Neither of the countries had created organizations for government-owned knowledge diffusion in 1991. Since the early- and mid-2000s, both China and South Korea have created or tasked organizations to promote the diffusion of often classified defence knowledge within the sector. Japan also tasked ATLA in 2016 to implement such activities, in parallel to the new “open and closed” strategy. Only China has promulgated a dedicated defence IPR law, with the other two countries instead having specific provisions in the general IPR regulations.

Both China and South Korea have been strict on knowledge diffusion, including DAPA’s right to classify or prevent IPR filings. Japan has implemented such a system in 2016, with ATLA creating an open and closed strategy to that end. The strategy is primarily aimed at transfers abroad, with ATLA being tasked to promote domestic diffusion. Previously, the 1958 Directive on Protection of Special Defence Secrets and the Directive on Confidentiality were utilized to impose restrictions on defence R&D and its results.

Here again the compromises between liberalization and classification demanded by advanced innovation policy become apparent. Both the Japanese and South Korean DPA organizations have gained the specific mandate to manage this dilemma between diffusion and retainment. Chinese efforts to declassify defence patents indicate the same policy direction. New schemes

to transfer IPR ownership and thus raise incentives have only been created by Japan and South Korea. It can be assumed that this is not seen as necessary in China, due to the strong role of state-owned entities.

Table 40 – Comparison: Arms and Technology Export Control

Institutions – Arms and Technology Export Control					
	<i>Arms Export Control</i>		<i>Technology Export Control</i>		<i>Int. Arms Treaties</i>
	1991	2021	1991	2021	1991 – 2021
China	executive orders	export licences and executive orders	not regulated	export licences and executive orders	2
Japan	banned	export licences	banned	export licences (except to the USA)	5
South Korea	export licences		not regulated		

Arms and technology export control are driven by political, financial, proliferation and technology retention considerations. In 1991, only Japan had a fully-fledged control regime embodied in an overall arms and technology export ban. While South Korea was in the early stages of creating a control regime through export licences, China relied on ambiguous executive orders. Neither of the two countries regulated technology transfers. South Korea established a fully-fledged arms export regime in 1993 and for technology exports in 1998. In China, an export regime was created in 1997 and technologies added in 2002.

Japan re-allowed exports in 2014, while South Korea consolidated its export regime through continuous expansions. In both countries export licences are required for both arms and technology exports. Although China has also enlarged its controls and integrated technology transfers, the continued parallel utilization of executive orders leaves room for ambiguity. This is also reflected in the signing of international treaties, where China has shown reluctance to accede to international control regimes.

It is thus evident that Japan and South Korea have adopted much stronger regimes than China. The reasoning for this cannot fully be explained, as too many factors such as moral values, foreign policy and diplomatic considerations, industrial revenue, and technology retention factor into such decisions. The increased regulation of knowledge outflows nonetheless

supports the argument that technology retention efforts have played a role. For both Japan and South Korea international cooperation efforts with the US and other Western nations likewise have had an impact, as shown by the origins of South Korea's system.

6.5. Policy Portfolio: Linkage Policy

Considering that linkage policy is an important tool for targeting systemic problems within the defence innovation system, the lack of similarities in context of the timeline is not unexpected. The strong integration of the DIS within the civilian industry in Japan made major linkage policy reforms obsolete. The Chinese DIS on the other hand was highly dysfunctional in the 1990s, thus domestic linkage policy started off targeting intra-defence sector issues, developing accordingly to the overarching linkage approach embodied in the MCF policy in the 2010s. Between these two extremes, South Korean domestic linkage policy developed along a gradual approach placing focus on specific issues such as defence-university and -SME links.

Table 41 – Comparison: Domestic Linkage Policy

Domestic Linkage Policy			
	<i>Domestic Policy Reform Focus</i>		
	1990s	2000s	2010s
China	intra-defence sector	civilian sector (CMI) spin-on	overarching (MCF) spin-on / spin-off
Japan	-	-	armed forces – university linkages
South Korea	universities and public organizations spin-offs	SMEs and start-ups spin-on/spin-off	overarching

During the late 2010s, both China and South Korea have reached a stage, where their linkage policy is best described as “overarching”, in line with current innovation policy. While promoting and supporting linkages in every field, there are no major systemic failures that receive heightened attention. In Japan on the other hand, the DPA has had limited success in tackling the lack of collaboration between defence agencies and universities. The changes in linkage policy display both the progress from the classical to late-classical and NSI approaches, as well as the demands created by the transitional defence sector.

Foreign linkage policy has likewise been steered by foreign policy objectives, and indigenization and absorption policies, as well as been impeded by restraining factors. While Chinese collaboration and import opportunities have been limited by the 1989 Western arms embargo, Japan retained its self-imposed ban until 2014.

The reasoning for utilizing foreign linkages has distinct differences between the three nations. Japan had already an advanced DIB and was confronted with not falling behind. It primarily utilized collaboration with the US, and more recently other partners, to forestall the feared “Galapagos effect” of losing pace with the state of art.

Both China and South Korea were for a considerable part of the assessment phase still in the process of catching-up to other international competitors. While South Korea aimed a pursuing a gradual, sustainable increase of its DIB’s sophistication and expanding opportunities for international collaboration, Chinese policy underlined the need for “leap-frogging” and thus omitting certain stages of development.

Table 42 – Comparison: Foreign Linkage Policy

Foreign Linkage Policy						
	<i>Restraining Factors</i>	<i>Utilization Reasoning</i>	<i>Policy Focus</i>			<i>International Partners</i>
			1990s	2000s	2010s	
China	Western arms embargo	leap-frogging	reverse engineering limited licenced production	limited collaboration industrial espionage dual-use collaboration (DIEGs)		Russia, Israel, former Soviet States, other non-Western partners Europe (DIEGs)
Japan	self-imposed ban	keeping up to date preventing Galapagos effect	licenced production (USA) indirect offsets		licenced production (USA) limited collaboration	United States Western and Asian partners (2014 onwards)
South Korea	-	gradual increase of sophistication	licenced production (USA) technology transfer offsets		collaboration	global

The policy focus has developed in line with these overarching considerations. While all three nations have utilized licenced production at some point, China did so only with a limited scope. Both Japan and South Korea have relied on US products for licenced production and the interlinked learning process and technology transfers. Both countries have also utilized offsets,

with South Korea extensively utilizing the tool for technology transfers. China, on the other hand, put reverse engineering at the forefront of learning, with licenced production utilized for filling capability gaps. It is also the only of the compared cases with a considerable known industrial espionage programme.

The clear focus on knowledge flows is visible in foreign linkage policy, albeit different tools were utilized to that end. Japan's inability to enable the bi-directional technology flows demanded by partners has led to the abolishment of its export ban. South Korea's strong efforts to import knowledge through offsets and licenced production has graduated likewise towards bi-directional flows demanded and enabled by increased domestic capability. While China has become less reliant on already limited licenced production, bi-directional flows are primarily conducted through dual-use cooperation.

Towards the end of the assessment phase in the late-2010s, South Korea has moved forward to becoming a defence innovation leader being on par in many fields, shifting policy focus to collaborative projects. Japan as well has strived for increased collaboration, retaining licenced production of sophisticated platforms both due to financial and political considerations. Likewise, China has moved away from reverse engineering, but still relies on industrial espionage. Collaboration activities have remained limited in scope and numbers, primarily restricted to Russia and other former Soviet states. The increased scope of South Korean collaboration is telling on its increased domestic capability, which also applies for China.

The restraining factors are reflected by the availability of international partners. South Korea has the most extensive network of technology cooperation agreements, transcending both geographical and political lines. China on the other hand is primarily collaborating with Russia, former Soviet countries, as well as other non-Western partners, and Israel. Japan has extended its network of partners beyond the USA since 2014, but is still limited to Western and Asian partners, as well as by the number and depth of joint projects. Here technology retention and reluctance for bi-directional flows are still a major factor.

6.6. Networks

Networks have expanded in all three countries, driven by the inclusion of new and emerging industries with relevance for defence. Both in China and South Korea agglomerations of the classical defence industry had developed interlinked with heavy and machine industries in line with policy priorities. These were on one hand the Third Line policy, on the other the Yulgok Project. This is a marked difference in comparison to Japan, where Japanese defence enterprises were from the beginning integrated with the civilian economy.

In 1991 the Chinese defence industry was geographically separated from the rest of the economy, while the South Korean one only overlapped with it. These agglomerations have persisted and new civilian high-technology agglomerations have emerged. In South Korea new industries have partially developed in the same areas, such as the Seoul Metropolitan Area. In China, the defence enterprises concentrated inland had to create new subsidiaries in the coastal provinces to connect to the new high-technology economy. Until 2021, both countries' DIBs have linked and partially integrated with the civilian economy, highlighting the geographical aspect of the transitional defence sector.

Table 43 – Comparison: Agglomerations and Clusters

Networks						
	<i>Classic Defence Industry Agglomerations</i>		<i>Geographic Relation to High-Technology Agglomerations</i>		<i>Clusters</i>	
	1991	2021	1991	2021	1991	2021
China	Western China, Liaoning	Western and Coastal China	separated	partially integrated	-	MCF clusters sector-specific hubs
Japan	general economic agglomerations		integrated		-	-
South Korea	Gyeongnam-Busan-Ulsan, Seoul Metro, Chungnam-Daejeon		overlapping	partially integrated	Changwon, Daejeon	sector-specific clusters

Japan has not implemented a defence cluster policy during the assessment period. South Korea on the other hand was the only country that had de-facto defence industry and R&D clusters in 1991. Both in China and South Korea additional sector-specific clusters were developed, often driven by local government initiative. South Korean defence cluster policy is a rather recent addition, but it profits from the already established de-facto clusters in certain technological fields. In China, the MCF policy includes the creation of MCF demonstration zones that represent defence-civilian clusters. These are created both by national and local governments. Here again integration efforts and tendencies of the transitional defence sector are visible.

Table 44 – Comparison: Civilian-Defence Partnerships

Networks			
	<i>Civilian-Defence Partnerships</i>		
	China	Japan	South Korea
1991	-		Daejeon R&D cluster
2021	university defence research laboratories MCF clusters	limited ATLA-university collaboration	university research centres integrated clusters

In 1991, only South Korea had a permanent civilian-defence collaboration scheme with its R&D cluster in Daejeon. Neither China nor Japan had comparable permanent partnerships. Within the assessment period, both in China and South Korea further clusters were developed, as aforementioned. Additionally, in both countries the DPAs have created research facilities at universities. In China, this also encompasses university facilities established in cooperation with the DIEGs. Although Japan's ATLA aims to follow-up in this regard, efforts have so far had limited success. The intent to promote linkages and integration are thus similar in all three nations, with a lagging implementation in Japan and an overarching scope in China.

6.7. Policy Portfolio: Financial Policy

The crucial source for funding is still the national defence budget. The DIBs in all three countries were affected by budgetary constraints during the 1990s. These constraints were linked to falling defence budgets in the wake of the ending Cold War. The Chinese and South Korean DIBs became profitable again after 2002, while the Japanese one lagged.

Both China and South Korea increased their military expenditure in absolute terms throughout the assessment period, reflected in growing acquisition and R&D budgets. Japan's defence budget on the other hand fell from 1997 until 2012, before recovering. Its overall performance nonetheless is little more than stagnation, compared to the growth in the other two countries. The dedicated defence R&D budget is very limited, but defence enterprises profit from the overarching public R&D funds that also target dual-use areas.

In line with techno-nationalism, all three countries employ a nurturing policy of differing degrees to support their DIBs. Both China and South Korea utilize a broad spectrum of preferential treatments, such as reduced taxes and tariffs, low-interest loans, and additional forms of administrative and financial support. Japan on the other hand has not relied on such tools. It sustained enterprises through contracting arrangements within the Kokusanka projects,

as well as incentivized sectors with lacking interest in defence production with cost-plus contracts.

Table 45 – Comparison: Financial Policy

Financial Policy				
	<i>Overarching Approach</i>	<i>Preferential Treatments</i>	<i>Direct Funding Mechanisms</i>	<i>Other Policy Foci</i>
China	nurturing policy	financial transfers tax breaks low-interest loans public loans	dual-use R&D funding programmes government guidance funds (2008)	budgetary independence for DIEGs (1999) private investments, stock market listings (2007-2016)
Japan		cost-plus contracts for certain sectors (1990s)	Kokusanka projects Innovative Science & Technology Initiative for Security programme (2015) de facto dual-use funding	spin-off promotion (1990s) defence export promotion (2014)
South Korea		reduced and exempted taxes and tariffs low-interest loans legal and administrative support	Defence Industrial Promotion Fund (until 2006)	defence export promotion (2000s onwards)

In comparison, both Chinese and South Korean defence R&D actors are much more reliant on dedicated defence R&D funding than in Japan, where dual-use funding is dominant. These countries also employ a much broader scheme of preferential treatments in line with classical assumptions of innovation theory. Direct funding mechanisms have been employed by all three countries, but most notably in China. Contemporary mechanisms are geared towards similar goals of civilian-defence integration: in China the MCF guided governments funds, in South Korea the ICMTC budget, and in Japan the Innovative Science & Technology Initiative for Security and to some extent the ImpACT programme. Here again attention has shifted to knowledge diffusion and linkage promotion between the civilian and defence industries.

The three countries have also emphasized different policy tools to further nurture the defence industry and provide additional funding resources. In China, this included the commercialization of the defence industry in 1999, entailing budgetary independence. Furthermore, since the reform wave of 2007 to 2016, the DIB has access to private investment and the stock market.

In Japan, public promotion and support of spin-off production was designed to incentivize enterprises to partake in defence R&D. Like in South Korea, ATLA strives to promote defence exports since 2014. In South Korea, this defence export promotion programme has continued since the 1990s and subsequently received increasingly more attention. Its success is reflected by the expanded volumes of defence exports in the 2010s. Like in China, South Korean defence enterprises have thus gained additional revenue from sales abroad.

6.8. Policy Portfolio: Acquisition Policy

In the field of acquisition policy, all three nations have aimed to increase competition, introduce new evaluation tools, and increase supervision and transparency mechanisms during the last thirty years. While other issues were also the target of reforms, these were the one's stretching throughout the period. Driven by the demand for indigenous innovativeness, competition in acquisition contracts has been considerably expanded by all three. Nonetheless, due to the limited number of capable suppliers and secrecy considerations, for major acquisitions limited- or sole source-contracting prevails.

Table 46 – Comparison: Acquisition Policy

Acquisition Policy				
	<i>Competition</i>	<i>Evaluation</i>	<i>Supervision/Transparency</i>	<i>Other</i>
China	1998 (Four Mechanisms)	2009 onwards / 2014	1998 (Four Mechanisms) 2012 onwards (anti-corruption campaign) 2015 (WEIAN)	demand-pull system (1998) pricing reform (2009/2014/2016)
Japan	1999 (majority of competitive contracts) 2005 (majority of value of contracts)	1995 onwards (cost-reductions, life-cycle management) 2020 onwards (comprehensive evaluation bidding system)	1998, 2007 (continuous transparency reforms)	-
South Korea	1991 onwards (gradual redesignation for bidding) 1996 (expansion of bidding) 2006 (end of specialization) until 2016 (uni-resource, multi-supplier system)	1997 onwards (life-cycle management)	1993 (auditing and inspections) 1996 (transparency clauses, new information policy) 2014/2018 (additional measures)	SME nurturing (1996 onwards) domestic production (2008) risk reduction (2016)

The reasons behind the lack of competition, the monopolistic structure of the defence sector, have been shaped by national policy. In China, the Machine Ministries and later DIEGs were organized around technological fields, thus there was and, in some fields, still is only one supplier. This characteristic persists, limiting the possibility to achieve competition through acquisition policy. In Japan, competition was deliberately prevented through procurement management in line with the Kokusanka policy. In South Korea, the specialization system designated suppliers for specific technological fields. ADD and selected suppliers operated without any competition when it came to domestic R&D preceding procurement. The expansion of competitive tenders has thus been also limited by the thereby established market structure, with competition primarily being introduced for small projects, where a larger number of suppliers is available.

Incorporating additional issues for evaluation has also received attention in all three countries. Both South Korea and Japan have integrated new assessments since the late-1990s, such as for life-cycle management and cost reductions. China only incorporated additional evaluation factors in 2009, addressing similar issues. All three countries have also strived for tackling corruption in the system since the 1990s. In both Japan and South Korea, this has been driven by public corruption scandals linked to backchanneling for procurement projects. In China on the other hand the overarching, politicised anti-corruption campaign under the Xi Jinping administration also targeted the defence sector from 2012 onwards.

Both South Korea and China have improved the transparency of acquisition tenders to forestall such backchanneling and incentivize new suppliers to partake. In South Korea, this was implemented through a new information policy in 1996. In Japan, the comparable Medium Term Defence Programme has been published since 1986. Both Japan and South Korea publish procurement tenders per public notices or respective web portals. In China, the creation of the WEIAN platform in 2015 was essential to provide information for incentivizing civilian participation.

Acquisition policy in all three countries has thus been reformed, taking into account the insights of the chain-linked innovation model, and abandoning the supply-push concept of the pipeline model. The factors of competition, evaluation, and transparency are central for promoting innovation and have been adopted by all three DPAs. To what extent this effort is successful can hardly be assessed, but implementation was delayed and has been gradual. Major acquisitions are still not handed out in a competitive fashion, both due to secrecy considerations and the actual market structure preventing it.

China and South Korea have emphasized additional issues in their acquisition policy reforms as well. Pricing reform has been implemented by all countries but featured much more prominently in Chinese efforts in the 2010s. Essential for China was the establishment of a demand-pull system by separating defence acquisition and procurement in 1998. This specifically in light of state-owned enterprise monopolies, where even limited competition has been hardly achievable. Specific endeavours such as South Korea's SME promotion display the demand for NTBFs, as predicted by theory. The country also aimed to raise incentives through the mitigation of risk and uncertainty in the late-2010s, addressing a problem that is both central to classic and advanced innovation theories. Likewise, localization remains an important issue in Japan and South Korea, both in respect to supply reliance and export opportunities impeded by the US ITAR controls.

6.9. Policy Portfolio: Human Resource Policy

The approach to human resource policy has vastly varied between the three countries. China has been confronted by deeper systemic problems than both Japan and South Korea. On the one hand, there existed at the same time both an overcapacity and a lack of qualified personnel in the defence industry of the early 1990s. This was a result of the Third Line Policy, the Cultural Revolution, and the much higher attractiveness of civilian industries.

Table 47 – Comparison: Human Resource Policy

Human Resource Policy			
	<i>HR Issues</i>	<i>Talent Recruitment</i>	
		<i>Domestic</i>	<i>Abroad</i>
China	downsizing; lack of qualified labour and incentives, politicization (1990s/early 2000s)	universities (recruitment centres) 511 “grooming” project Double First-Class University Plan (2015)	Thousand Talents Programme +200 recruitment programmes, +600 recruitment stations PLA/DIEG/defence R&D
Japan	corruption scandals and ban of re-recruitment (2007)	universities special research officer system (2016)	-
South Korea	democratic control and civilian oversight, civilianization (2005 onwards)	universities defence acquisition education system	-

The problems were tackled by the interlinked commercialization of the defence industry and the downsizing of the workforce, a boost to university funding to increase the output of

graduates, and the creation of new incentives. In addition, the politicised chief-designer model, which linked project and personnel success, and limited accountability, was replaced by modern project management methods and competitive management choices

In contrast, neither Japan nor South Korea had similar systemic failures. While the Japanese defence industry lost nearly 10 percent of its technicians during the economic downturn of the late 1990s, no policy response was deemed necessary. Both defence industries are in private hands, and thus recruitment is handled by enterprises themselves. To counter problems of corruption and back-channelling, Japan banned the recruitment of public officials by the defence industry, while South Korea attempts to civilianize DPA organizations since 2005. The Chinese government thus takes a much stronger role in respect to HR issues of the DIB, necessitated by its state-owned defence industrial model.

Domestic talent recruitment in all three countries is facilitated by recruiting graduates directly from universities. Japan utilizes an examination system akin to the recruitment of all public officials, as well as ad-hoc recruitment of experts with needed expertise, such as in programme management. South Korea is also able to recruit personnel while they complete the compulsory military service. The country also utilizes a substantial defence acquisition education system for both public and private sector personnel in their respective areas of defence acquisition, defence research, and export regulations. While similar education systems eventually exist within the Chinese DPA, the ROK approach stands out as it also incorporates personnel from private industries.

China has the most extensive university recruitment programme, having more than 2500 PLA recruitment centres at universities in 2019 and dedicated recruitment plans. In addition to the aforementioned university funding programmes, a dedicated “511” project exists to recruit outstanding researchers and scientists for PLA defence projects. The 2015 Double First-Class University Plan, which aims to make 98 universities world-leading institutions by 2050, is also linked to the MCF policy.

Of the three countries, only China has a significant policy to recruit personnel overseas. This is a policy response to a continuous brain drain, primarily towards the US. While primarily aimed at ethnic Chinese, the Thousand Talents Programme includes a sub-programme targeting foreign citizens as well. Both the PLA and sub-organizations, and the DIEGs utilize these programmes for recruitment. These efforts have been successful, with experts being recruited for crucial areas of AI and nuclear physics, among else.

Considering the element of human resource policy, public organizations in China take a much greater role both in management and recruitment. Its foreign recruitment programme displays efforts to promote knowledge import through incentivizing knowledge holders. In both South Korea and Japan, the industry is left alone with respect to recruitment, while recruitment for DPA organizations is handled through standard public examination programmes. Japan's special research officer system can be assessed as an effort to incentivize knowledge flows where public organizations lack it. South Korea's defence education system on the other hand is a special feature with no pendant in Japan. The education of personnel from private industries in both trade aspects and technical knowledge displays an extended approach to learning and presents another form of knowledge diffusion promotion.

6.10. Summary

Similarities between all three countries have increased during the 30-year period. All three follow the same overarching policy strands of techno-nationalism, indigenization and absorption, and boosting domestic supply reliance. The same can be said for planning tools, where dedicated plans have been created. Nonetheless the timeframes vary between countries and Japan has yet to establish continuity. The subsequent summary is structured in order to present overarching similarities, as well as those between two of the countries, in parallel displaying the major differences.

Similarities of All Three Defence Innovation Systems

During the assessment period, all three countries implemented similar reforms. These have been guided both by advanced approaches of innovation theory focusing on networks and knowledge flows, and by demands of the transitional defence sector on civilian-defence integration. These trends of managing the trade-offs between classification and liberalization can be tracked in all three case studies. Notably, Chinese reforms liberalizing market access, opening the stock market to defence enterprises, and allowing domestic and foreign private investments, have aligned it with the approaches of Japan and South Korea.

In 1991, important similarities between the DIS in all three nations were:

- the fragmented DPA structure and relationship to the armed forces;
- the management of IPR regulations (specifically on government funded R&D and technology diffusion);
- the utilization of licenced production;
- and the focus on financial nurturing policy.

Similar trends nonetheless have not always resulted in the same features. The DPA organizational structure was integrated both horizontally and vertically, but the Chinese version ended-up with different features than the other two. Reforms in acquisition policy encompassed competition, evaluation, supervision and transparency issues have targeted the same areas, but foci and goals were guided by the respective DIS frameworks.

By 2021, important similarities between the DIS in all three nations were:

- respective Ministries of Industry had a mandate for defence industrial policy;
- the regulated permittance of domestic and foreign private investments;
- the stock market access for defence enterprises;
- the open market access, solely managed through acquisition policy;
- the domestic technology transfer management (organizations with mandate for both knowledge diffusion and classification);
- the focus on financial nurturing policy with an increasingly overarching perspective;
- and the utilization of direct recruitment from universities.

Thus, while approaches have diversified in regard to DPA structure, IPR management, and the utilization of licenced production, other similarities have emerged. This specifically concerns the access to new financing sources, increasing competition through the entrance of new actors, and the promotion of domestic and foreign technology transfers. All these issues have been identified as crucial by the NSI approach introduced in chapter 2.3.

Specifically due to the alignment of Chinese policy, but also due to reforms in the other two countries, these similarities have emerged from the ambition of alleviating systemic problems in the DIS. In general, China has been the last of the three nations acting on these issues, with the notable exception of Japan's policy on foreign linkages.

Assessing similarities between two of the three case studies intriguingly shows that China and Japan have the least in common, while South Korea shares considerable similarities with both China and Japan. In 1991, the only similarities between the Japanese and Chinese DIS were in fact that both suffered from restraining factors affecting their foreign linkages. While in China these were foreign sanctions, in Japan it was a self-imposed ban.

By 2021, Japan had given up its ban on arms and technology exports. Despite that, both Japan and China continue to be affected by limitations on international collaboration, and the geographical and political variety of international partners. South Korea on the other hand has established global collaborations transcending both geographical and political lines.

Similarities between the Chinese and South Korean DIS

In 1991, the South Korean and Chinese DIS shared the following features:

- established, comprehensive planning portfolios;
- main research actors were state owned;
- foreign investments in the defence sector were banned;
- technology exports were not regulated;
- defence agglomerations existed;
- preferential treatments such as reduced taxes, tariffs, and public loans were utilized;
- and funding programmes were employed.

The continuous similarities between China and South Korea are primarily linked to networks, linkage policy, and financial policy. This is due to Japan's integrated economy, where defence agglomerations and clusters have neither emerged nor been promoted. Likewise, continued problems of Japan's ATLA to establish direct networks with civilian universities have forestalled the development of comparable linkages. Japan also deviates in respect of its financial policy, with slowly increasing defence budgets and limited defence R&D funding.

In 2021, the South Korean and Chinese DIS shared the following features, separating them from Japan:

- defence agglomerations with partial (geographical) integration to high-technology industries existed;
- defence clusters existed;
- notable civilian-defence partnerships had been established;
- and the aforementioned preferential financial policies were utilized.

Other shared features have disappeared due to policy changes in one or both countries. While China continues to primarily rely on state or state-owned R&D actors, South Korean ADD's mandate has been drastically narrowed to crucial technologies, increasing the relevance of private R&D. South Korea has also continued to strengthen arms and technology export regulations, while China has taken only limited steps in that direction. Both countries have liberalized investment regulations as aforementioned, bringing it in line with Japanese policy.

Similarities between the Japanese and South Korean DIS

Japan and South Korea have crucial similarities that separate both from China. This is the reliance on a private defence industrial base, by 2021 also including important private R&D

actors, and on single, partially civilianized DPA organizations outside of the armed forces. In contrast to China, the defence markets in the two nations are both monopolistic and duopolistic, compared to the solely monopolistic Chinese market.

In 1991, the South Korean and Japanese DIS shared the following features:

- defence industrial policy was handled by respective Ministries of Industry;
- a monopolistic/duopolistic defence market structure;
- a privately owned defence industry;
- domestic private investment was permitted and regulated;
- access to stock markets was allowed for defence enterprises;
- and offset policies were utilized.

In 2021, the South Korean and Japanese DIS shared the following features:

- the DPA was organized in a single, partially civilianized entity outside of the armed forces;
- a privately owned DIB within a monopolistic/duopolistic defence market;
- the main research actors were privately owned;
- government funded R&D results could be transferred or jointly-owned;
- the comprehensive export licence system for arms and technologies;
- both were signatories of all major international arms treaties;
- the utilization of considerable public arms export promotion policies;
- and no recruitment programmes were employed abroad.

Both countries also have employed similar policies for foreign technology transfers (offset policies), although South Korea has recently started to transition to local component ratios instead. Further similarities are the liberalization of R&D result ownership regulations, the considerable public promotion of defence exports, and the strength of arms and technology export regimes. While China possesses an arms and technology export regime, it is considerably weaker due to the relevance of executive orders. Likewise, the Chinese government promotes defence exports, but not in the scope of DAPA's and ATLA's undertakings. Neither country has created recruitment programmes abroad, in contrast to considerable Chinese efforts to recruit both overseas ethnic Chinese and foreigners.

7. Conclusion

7.1. Similarities and Differences

The analytical comparison has shown that while there are considerable parallels in the management of defence innovation systems in the three countries, there are also clear differences. To reiterate, the research question posed in the thesis introduction was:

What are the similarities and differences between the defence innovation systems in China, Japan, and South Korea during the period of 1991 to 2021?

The different economic models between China's state-owned industry, and South Korea's and Japan's liberalized economies are mirrored by the respective defence innovation systems. This is displayed by Chinese reliance on state-owned defence industrial enterprise groups and the DPA's organization with the PLA.

When setting aside this difference, the picture is much less clear. All three governments take an important role in their respective defence innovation systems. While China and Japan share only a limited number of policy approaches, South Korea does with both. In general, the similarities of policy approaches by all three countries have increased within the assessment period. This is specifically visible in the fields of acquisition policy, domestic and foreign linkage policies, and investment, market entry, and arms and technology export control.

The success of these shared policies has varied, specifically in the scope of linkage policies. Each of the three DIS has specific strengths separating them from one another. In China, it is the extensiveness of the MCF policy, the linked funding programmes, and defence and dual-use clusters. In Japan, it is the depth of the integration of defence and civilian sectors, featuring elements such as "hotbed facilities" that are utilized for both defence and commercial production. In South Korea, it is the reach of international collaborations, extending both geographical and international political separations, and an extensive public export promotion system.

Figure 16 displays the most important similarities and differences of the three compared countries in 2021. In the centre are overarching similarities. These include 1) the centralization of DPA organizations through horizontal and vertical integration; 2) the liberalization of investment regulations and market access; 3) increased knowledge diffusion efforts within the DIS; and 4) the financial nurturing of the defence industry with varying mechanisms.

On the edges are important similarities between two of the countries, the third being the “odd one out”. These include 1) overarching domestic linkages in China and South Korea, in contrast to Japan’s lack of integrating the university sector; 2) reliance on a private defence sector in Japan and South Korea, in contrast to China’s state-owned industry; and 3) limitations on foreign partnerships, in contrast to South Korea’s extensive collaboration network.

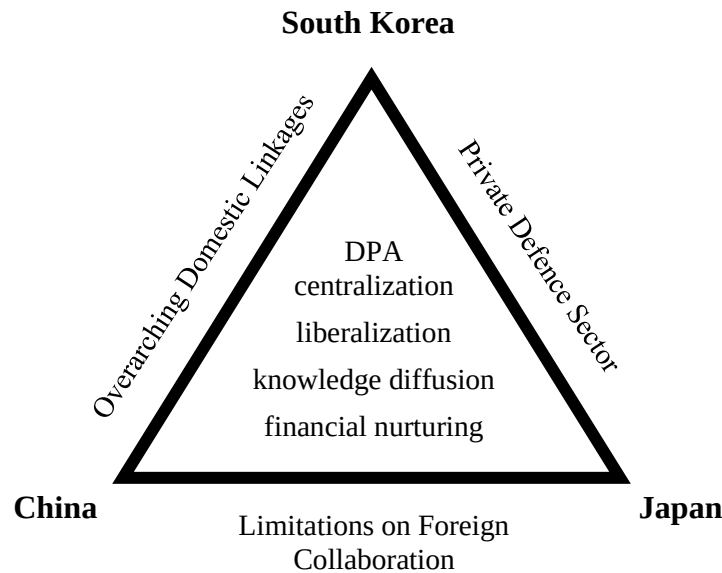


Figure 16 – Most Important Similarities and Differences between the Three Compared Countries in 2021

7.2. East Asian Defence Innovation Systems and Innovation Theory

The thesis results outline comparable policy approaches designed to boost domestic innovation capabilities and supply reliance. Classical approaches to government intervention are reflected in the policy portfolios of all three countries, but throughout the assessment period the shift towards advanced innovation theories can be tracked. This is specifically visible in the growing focus on domestic linkages, embodied in the elimination of sectoral delimitations, the founding of clusters, and the promotion of collaboration of research entities and industry on the one hand, and private and public actors on the other. With limitations, the same is applicable to foreign linkages, although both China and Japan remain limited in establishing deep and long-lasting ties.

The classic approach to facilitate crucial research internally, thus crowding out private investment, has likewise been reduced in both China and South Korea. China was the last of the three to transfer from the classical supply-push towards the market-pull model, in line with Kline and Rosenberg’s (1986) advanced chain-linked innovation model. In South Korea, recent efforts to reduce risks for R&D actors mirror the concept of managing risk and uncertainty by

Bergek et al. (2010). Likewise, lessons taken from Edquist's (2005) "concept of learning", a central element of the NSI approach, are visible in South Korea's defence acquisition education system.

It is thus clear that all three compared countries have advanced from government intervention guided by classical innovation theory towards late-classical and NSI concepts, which focus on networks and linkages. The same applies for the transformation of the defence sector in line with the concept of the transitional defence sector. The effort to integrate civilian and defence industries, as well as the civilian university sector and NTBFs, clearly displays this evolution.

Concepts such as path dependency and systemic failures are relevant to the assessment of the national DIS, as outlined in the respective case studies. While the former is closely interlinked with the policy driven creation of monopolies in all three countries, historic systemic failures can be identified in varying fields, such as linkages, human resources, and finance. There is a growing focus on defence SMEs and cluster policies, specifically in South Korea, but to some extent also in the other two countries. This falls under the idea of "new-technology-based firms (NTBFs)" as described by Boekholt (2010), which are highly relevant for network focused innovation theory.

Both the Chinese and South Korean governments still link the defence sector with positive externalities for achieving macroeconomic goals, as expected by the classical theory. In China, this is visible in the integration of defence into any aspect of macroeconomic planning under the MCF policy. In South Korea, the defence sector has been designated as a "national growth engine", with the expectation of growing revenues and employment. Despite that, all the compared countries' defence industries have clearly evolved from the classical defence sector to the transitional model.

In the context of Chinese defence industrial policy, Cheung (2009a, 137) has utilized the term "neo-techno-nationalism". It refers to the pursuance of techno-nationalist goals through the utilization of globalization. As the increased focus on foreign linkages has shown, the term could indeed also be applied to South Korea and Japan.

The applied analytical framework has also proved its applicability of providing a timeframe analysis of the evolution of national defence innovation systems. Although results have been somehow impeded by data availability, specifically regarding the period before 2000, they have been detailed enough for a comprehensive comparison. They display that a superficial assessment according to liberal and state-dominated economies is misdirecting. The elements

of the DIS and the strategic innovation system management enable an in-depth assessment of the intricacies of the evolution of national defence innovation systems.

7.3. The Global Context

The comparative analysis forestalls the idea of a shared East Asian DIS approach. There are considerable similarities present, which have in fact increased over time, but also notable differences. Most importantly, the concept of a separate East Asian approach to defence innovation systems would entail a unique approach compared to global, specifically Western, defence innovation systems and reform efforts.

The newly emerging EU DIS provides an exemplary case for a cursory comparison. The EU DIS is a unique effort to integrate the existing defence industries of the EU member states. It complements a more overarching effort to establish shared, complementing defence capabilities in the mid- to long-term. Assessing the steps taken so far, the same foci displayed in the assessed case studies can be identified. These include the creation of central DPA organizations and the overarching emphasis on linkages.

The inter-governmental European Defence Agency (EDA) was created in the frame of a “joint action” in 2004 and subsequently elevated to full organization in 2011. 26 EU member states and 4 external partners collaborate within EDA. It is tasked with supporting defence capability development and cooperation, and promoting defence research and technology, with a strong focus on creating and improving linkages (EDA 2022). Within the agency, a defence innovation hub focusing on innovation and disruptive technologies, as well as start-up and SME promotion, is planned to be established in 2022 (Tigner 2022).

The EU has also created a dedicated Directorate-General for Defence Industry and Space (DG DEFIS) in 2021. It bears responsibility for the defence industry, respective innovation efforts, and the EU space programmes. Most notable of these is the European Defence Fund launched in 2021, which targets defence R&D activities. The fund specifically provides funding and support to cross-border consortia of defence firms and SMEs, as well as for undertakings benefiting capability development in the frame of other EU programmes (European Commission 2021b). Additional defence-oriented EU programmes, such as the capability-oriented PESCO, likewise focus on intensifying linkages and shared capabilities, often by providing dedicated funding.

While the EU presents a unique case due to its supranational character, efforts towards boosting the capacity and innovativeness of the defence industry clearly display parallels to the reforms

implemented by the three East Asian nations. The same can be said for the undertakings by EU member states, such as France, and AUKUS nations. These were introduced in Table 7.

Thus, further in-depth research integrating a comparison of Western defence innovation systems is necessary to enable further conclusions. The preliminary result is that policy adaptations to boost defence innovativeness and linked systematic changes are too similar in both Western and East Asian nations to support the idea of an “East Asian model of defence innovation”, especially in light of the existing differences between the East Asian nations.

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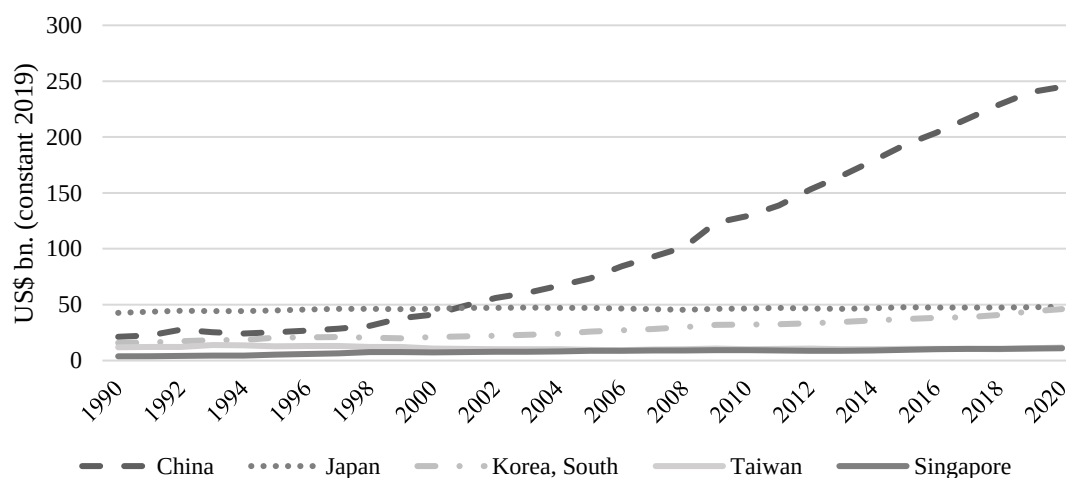
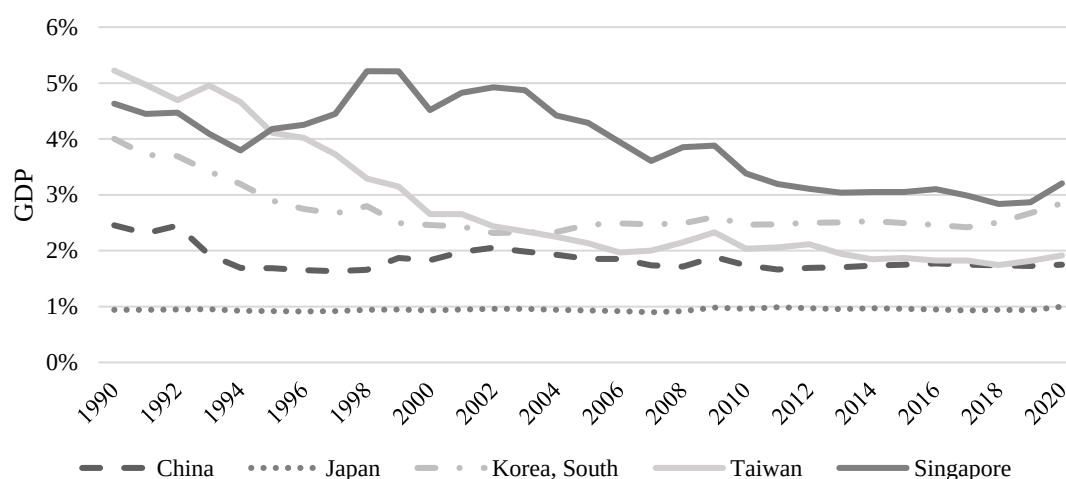
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Appendix 1 – Military Expenditure in East Asia

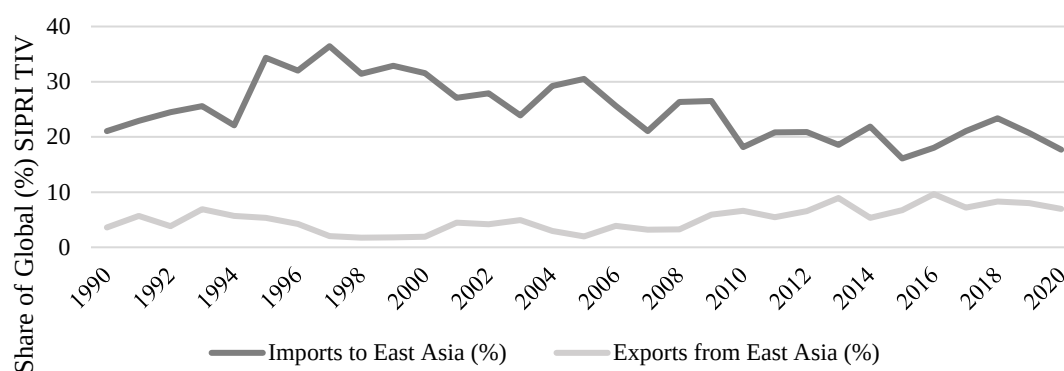
Military Expenditure by the Top-5 East Asian Spenders 1990 – 2020
(SIPRI 2021b)Military Expenditure by the Top-5 as Share of GDP 1990 – 2020
(SIPRI 2021b)

Relative Share of Military Expenditure in East Asia, Top-5 Spenders (SIPRI 2021b)

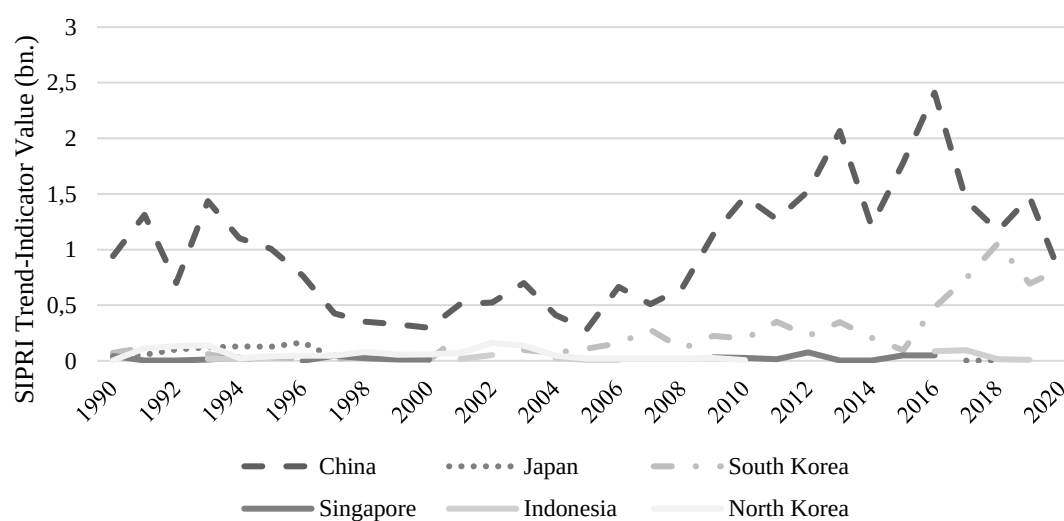
Country	China	Japan	South Korea	Taiwan	Singapore	Total
1990	19,9%	40,0%	14,9%	11,0%	3,6%	89,4%
2020	62,7%	12,3%	11,8%	3,0%	2,8%	92,7%
Growth Factor	11,5	1,1	2,9	1	2,9	-

Appendix 2 – Arms Trade in East Asia

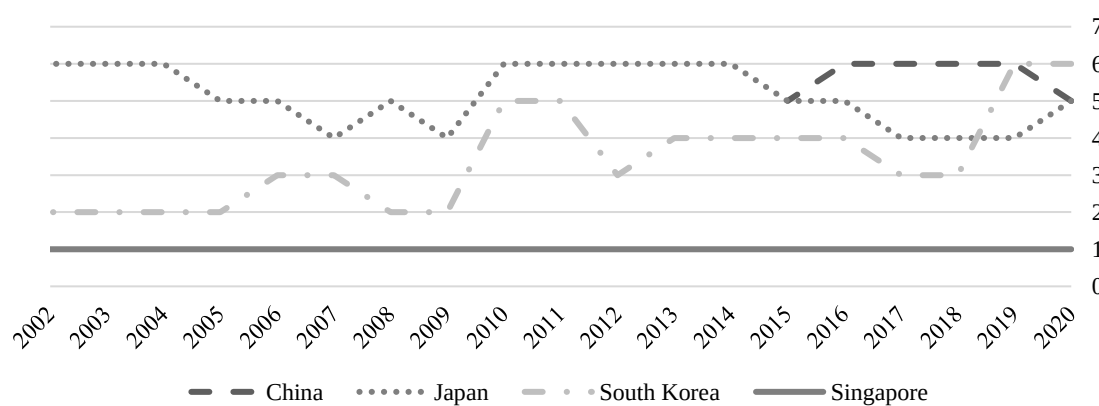
East Asia in the Global Arms Trade 1990 – 2020 (SIPRI 2021a)



Arms Exports from East Asian Countries 1990 – 2020 (SIPRI 2021a)



Number of East Asian Top-100 Defence Enterprises 2002 – 2020 (SIPRI 2021a)



Appendix 3 – Detailed Comparison of Overarching Tenets

	China	Japan	ROK
General Approach	techno-nationalism		
Name	Innovation with Chinese Characteristics	Kokusanka Policy	Koreanization (prev. Yulgok-Project)
DIB	state-owned industry, top-down management	private enterprises, strong governmental role	
Central Tenets 1991	selective resource allocation	limits on defence expenditure, nurturing policy/projects	strong, overarching nurturing policy
	isolated defence sector	unified sectors	delimitation through designation of defence enterprises
	indigenization through absorption	reliance on domestic supply ban on exports and limitation of foreign cooperation	indigenization licenced production offset trade and technology transfers
Major Policy Foci	marketization of defence enterprises “leap-frogging” integration of sectors (CMI, MCF)	end of export ban support for defence-academia exchange	DIB as new economic growth engine strong promotion and support for defence exports
	promotion of spin-off/spin-on and utilization of dual-use technologies		

Appendix 4 – Detailed Comparison of Planning Instruments

	China	Japan	ROK
Main Planning Cycle	5 years		
long-term	Weapons and Equipment Development Strategy (WEDS) (10-20yr.) Medium- and Long-Term Defence Science and Technology Development Plan (15 yr.) Weapons and Equipment Construction Plans (WECP) (10 yr.)	National Defence Programme Guidelines (~10 yr.)	Defence Reform Basic Plan (15 yr., updat. 3yr.) Defence Science and Technology Promotion Policy (15 yr., updat. 5 yr.)
mid-term	Weapons and Equipment Construction Plans (WECP) (5 yr.)	Defence Technology Strategy (DTS) Medium Term Defence Programme (MTDP) Medium- to Long-Term Defence Technology Outlook (5 yr.) Technology R&D Visions	Defence Planning Guidance Mid-term Defence Plan Basic Plan for Fostering the Defence Industry (5 yr., updated annually)
short-term	Weapons and Equipment Construction Plans (WECP) (1 yr.)	Comprehensive Strategy on Science, Technology and Innovation (1 yr.)	Force Enhancement Budget Defence Science and Technology Promotion Action Plan (1 yr.)
stand-alone plans	863-Plan (1986-2016) 995-Plan (1999-) China's Defence Science and Technology to 2000 (1986-2000) 2025 Defence S&T Industry Plan (2015-2025)	1970 Basic Policy for Development and Production of Defence Equipment 2014 Strategy on Defence Production and Technological Bases	-

Appendix 5 – Detailed Comparison of DPA Organizations

	China	Japan	South Korea
horizontal integration	est. of CMC General Arms Department (1998) est. of CMC Equipment Development Department, est. of CMC Science and Technology Commission (2016)	est. of Central Contract Office (2001) est. of JMoD, merger with Defence Facilities Administrative Agency (2007) est. of Acquisition, Technology and Logistics Agency (ATLA) and the Bureau of Defence Build-up Planning (2015)	est. of Defence Acquisition Office and MND Policy, Planning & Management Offices (1999) est. of Defence Acquisition Programme Administration (DAPA) (2006)
vertical integration	est. of CMC GAD (partial) (1998) 2016 est. of CMC EDD and STC (2016)	est. of ATLA and the Logistics Planning Department (2015)	2006 est. of DAPA (2006)
civilianization	est. of SASTIND (DIB policies) (2008)	est. of ATLA (2015)	est. of DAPA (2006, ongoing)
additional organizations	linkage promotion, defence IPR management, spin-on	-	linkage promotion, spin-on/spin-off

Appendix 6 – Detailed Comparison of Civilian Organizations

	China	Japan	South Korea
defence industrial policy	National Development and Reform Commission (NDRC) COSTIND/SASTIND (MIIT)	Ministry of Economy, Trade and Industry (METI)	Ministry of Trade, Industry and Energy (MOTIE)
defence and dual-use S&T and R&D funding	Ministry of Science and Technology (MOST) and predecessors Ministry of Education	METI Japan Science and Technology Agency (JST) and predecessors	MOTIE Ministry of Science and ICT (MSIT) Ministry of Economy and Finance (MOEF) other public organizations

Appendix 7 – Detailed Comparison of Actors

	China	Japan	South Korea
ownership	state-owned	private, limited public investment	
market characteristics	monopolistic (due to organization)	monopolistic/duopolistic (due to contracting policy) 75% of contracts handled by top-20 contractors	monopolistic (deliberate policy); efforts to change 75% of contracts handled by top-10 contractors
major reforms / transformations	corporatization into five SOEs (1993) reorganization into ten sectoral DIEGs (1999) merger of research institutes and SOEs into CETC (2002) 2018 merger of the nuclear DIEGs (2018)	consolidation of the shipbuilding sector, exit and bankruptcy of SMEs (late 1990s) consolidation of shipbuilding into Japan Marine United (2013)	consolidation due to financial stress (late 1990s) consolidation of aircraft production in Korea Aerospace Industries (1999) 2009 end of the designation system (2009)
Main research actors	primarily DIEGs and state-owned research institutes, defence universities increasingly also civilian entities	defence industrial enterprises and SMEs ATLA	ADD independent research institutes (increasing role since 2006) defence industrial enterprises
civilian-military industrial separation	CMI (since 2004) MCF (since 2016)	no separation	end of specialization system; de facto opening of the defence sector (2009)

Appendix 8 – Detailed Comparison of Ownership and Investment Regulations

	Important Laws, Reforms, Mechanisms	Content
China	1993 Corporate Law	base for the corporatization of SOEs
	2003 SASAC creation	DIEG ownership through SASAC
	2009 Law on State-Owned Assets in Enterprises	limited government interference State Council decides on enterprise transformations in strategic sectors
	2007 – 2016 reforms	stock market access, private investments in R&D and fixed assets definition of open, restricted, prohibited classes
	2015 Guiding Opinions on Deepening the Reform of State-owned Enterprises	SOE classifications and selective public support definition of defence enterprises as strategic, commercial SOEs with increased government protection and support
	2020 Foreign Investment Law Measures for the Security Review of Foreign Investments	foreign investments permitted, pending on review process
Japan	1948 Foreign Exchange and Foreign Trade Control Law, 1998 Foreign Exchange and Foreign Trade Act (superseding)	base for Ministry of Finance and MITI/METI to regulate foreign investments into the domestic industry; utilized to prevent investments in the defence industry
	2020 classification system (MoF) 2020 Foreign Exchange and Foreign Trade Act revision	established three categories; 1st category (strictest) encompasses all defence enterprises decreased limit for investments in 1 st category (from 10% to 1% of enterprise value) that require government approval
South Korea	1973 Special Act on the Defence Industry	designation system for defence industries
	1984 Foreign Investment and Foreign Capital Inducement Acts	prevented investments and acquisition of defence industries
	1998 Foreign Investment Promotion Act, 1998 Act on Special Measures for the Defence Industry Amendment	liberalized investments in ROK enterprises; restrictions and an approval requirement for investments in defence enterprises

Appendix 9 – Detailed Comparison of Market Access Regulations

	Important Laws, Reforms, Mechanisms	Content
China	2005 Measures to Implement Permission for Weapons Equipment Research, Development, and Production	established licences for participation in the defence economy
	2005 MIIT opens defence electronic projects to private firms	category 1 (advanced weapons and high-technology): for SOEs category 2 (subsystems and auxiliary work) projects: SOEs and private firms
	2012 Implementation Opinions for Encouraging and Guiding Private Capital in Entering Defence Industries	direct participation in weapons R&D is permitted for civilian actors
	2015 creation of the WEIAN platform	open information policy on contracts and tenders, targeting civilian actors
	2017 extension of the WEIAN platform	private actors can participate in defence tenders; de facto also in category 1
Japan	1952 Ordnance Manufacturing and 1953 Aircraft Manufacturing Industry Acts	MITI administrated licence system, controlling the extent of defence undertakings in the economy MITI can regulate access to different technology fields and prevent unwanted competition
South Korea	1973 Designation of Defence Materials and Industry Enterprises 1973 Specialization and Systematization System	closed the defence sector to non-designated enterprises designations managed by MOTIE ADD selects actors to participate in defence R&D
	1998 Act on the Promotion of Technology Projects for Joint Civilian and Military Use	legal basis for joint civil-military development projects
	2009 abolishment of Specialization and Systematization System	abandonment of designated suppliers for specific technology fields reduced entry barriers and increased competition designation of “major” and “general” defence contractors

Appendix 10 – Detailed Comparison of Defence IPR Regulations

	Important Laws, Reforms, Mechanisms	Effect
China	1985 Defence Patent System	IP gained through government funded research is owned by it; lack of specific IPR regulations; strong classification policy
	2004 Regulations on National Defence Patents	National Defence Intellectual Property Office established (subordinate CMC EDD)
	2017 Requirements on IPR Management for Equipment Manufacturers (CMC EDD)	first standard for defence IPR management, based on national IPR management clear legal framework for IPR in defence R&D, production, and tendering and bidding
	2017 declassification of patents	defence IPR can be utilized by private sector, strategic tech remains protected
Japan	1958 Directive on Protection of Special Defence Secrets and the Directive on Confidentiality	obliges enterprises to separate IPR systems for defence and civilian divisions
	1948 National Government Asset Act	IPR generated through public contracts is owned by government
	2002 Directive on the Handling of Rights to Patents (JDA)	ownership by research entity or joint ownership possible; for exceptions the company owns copyright and needs to consent to reproduction
	2016 Defence Technology Strategy (ATLA)	intellectual property control and evaluation of sensitive dual-use technologies incorporating an “open and closed strategy”, IPR disclosed or concealed
South Korea	1990 Patent Act	IPR gained through government funded R&D and offsets may be retained by government defence patents may be classified or their filing prevented
	2006 Defence Acquisition Programme Act	DAPA authority over defence IPR management; when DAPA funds R&D on weapon systems and defined core technologies, ownership is transferred to ADD; DAPA may grant licences
	2006 Enforcement Decree of the Defence Acquisition Programme Act amended	DAPA recognizes IPR by universities, public research institutes, and joint ownership when applicable
	2021 Defence Science and Technology Innovation Promotion Act	eases joint private-public ownership and transfer of IPR to research institutions

Appendix 11 – Detailed Comparison of Arms and Technology Export Controls

	Important Laws, Reforms, Mechanisms	Content
China	pre-1997 executive orders to approve arms exports	“Three principles of defence export”
	1997 Regulations on the Administration of Arms Export	codification of the three principles, based on 1994 Foreign Trade Law Article 4 establishes ban of weapon export that harms national interest or security continuation of ambiguous export regime, technology transfer not covered
	1998 SACMPT dissolution	COSTIND and GAD become main players, GAD main proponent in enforcing Article 4
	2002 Technology Import and Export Administrative Regulations	aim to safeguard Chinese defence innovation, and proliferation controls amended 2008 and 2020, including additional technology areas
Japan	1948 Foreign Exchange and Foreign Trade Control Law; 1949 Export Trade Control	MITI oversight of exports
	1967 Three Principles of Arms Export	restraining of defence exports
	1976 ban of all defence exports	overall ban, did not cover dual-use technologies
	1980 Foreign Exchange Order	specified restricted technologies
	1983 Japan-USA agreement	established case-by-case decision on transfer of technologies
	1998 Foreign Exchange and Foreign Trade Act	superseded 1948 Foreign Exchange and Foreign Trade Control Law, taking into account foreign exchange business
	2004 co-development agreement with US	for ballistic missile defence (BMD) systems, export conditions defined in 2011
	2014 Three Principles on Transfer of Equipment and Technology	replaced the 1976 export ban, reset of policy to 1967 allow joint R&D and defence exports

APPENDIX

	Important Laws, Reforms, Mechanisms	Content
South Korea	1987 bilateral agreement with the US	base for import certificate/delivery verification system in 1990
	1992 Foreign Trade Act amendment	export permit system for strategic items controlled by MOTIE (1993)
	1998 Act on Special Measures for the Defence Industry (1994) amendment	MND authority over knowledge transfer between public-funded defence research institutes and other actors
	1998 Act on the Control of the Manufacture, Export and Import of Specific Chemicals and Chemical Agents for the Prohibition of Chemical and Biological Weapons	base for export controls targeting technologies for biological and chemical weapons
	2003 Foreign Trade Act amendment	management of dual-use and general defence industry materials export
	2006 Defence Acquisition Program Act	DAPA permission required for all defence exports and technology transfers implementation of secrecy obligations on personnel in defence R&D amended in 2010 to control the sale of respective entities
	2007 Foreign Trade Act amendment	strengthening of export controls Public Notice on Trade of Strategic Goods and Technologies (regularly updated)
	2011 Nuclear Safety Act	base for export controls targeting nuclear materials and technologies
	2016 Defence Technology Security Act	establishment of the Defence Technology Security Committee and basic plan DAPA may designate defence technologies, putting them under the export control regime defence R&D actors must implement security measures to prevent leakage
	2020 extension of “situational licences”	extension to all conventional weapons, before only for missiles and WMD
	2021 Defence Science and Technology Innovation Promotion Act	entities infringing on security measures may be banned from defence R&D

Appendix 12 – Detailed Comparison of Domestic Linkage Policies

	Focus 1991 - 2021	Characteristics 1991	Reforms 1991 - 2000	2001-2010	2011-2021
China	overall links: intra-defence sector defence-civilian enterprise-research entities, universities MCF cluster policy	lack of linkages between sectors and within defence industry Military Representative Offices managing internal links COSTIND database and information centre since 1980s COSTIND liaison group with civilian partners	1998 GAD establishment – created central organization furthering DIB linkages 1999 DIEG consolidation DIEG joint ventures with universities, research institutes	2004 CMF 2007 national-defence R&D laboratories by COSTIND and leading universities MIIT Department for CMI Promotion Inter-Ministerial Coordinating Small Group for CMI	since 2012 Strategic Cooperation Framework Agreements (SASTIND) 2014 MCF (exhibitions, clusters, demonstration zones) 2017 Commission for Integrated Civilian-Military Development 2017 CMC Military Science Research Steering Committee 2018 Defence S&T Innovation Rapid Response Team in Shenzhen
Japan	armed forces – university links	integrated civilian and defence sectors strong, long-standing regional, inter- and intra-firm links lack of links between defence and universities	-	-	2013-2018 Impulsing Paradigm Change through Disruptive Technologies Programme 2015 Innovative Science & Technology Initiative for Security 2015 ATLA – tasked with SME technology spin-on
South Korea	defence – civilian links cluster policy	separated civilian and defence sectors, but enterprises engaged in both ADD as central actor managing linkages with R&D entities, universities, and defence enterprises ADD providing spin-offs	1998 Act for joint civilian and defence projects 1999 extended collaboration of MND with other ministries 1994 – 2000 MND- university research centres since 2000 ADD MoUs with universities and public entities	since 2003 DTAQ defence venture centres since 2008 Advanced Concept Technology Demonstrations (ACTD) since 2010 major uptick in ADD MoUs	2014 Institute of Civil-Military Technology Cooperation (ICMTC) – considerable budget for spin-off and spin-on promotion funded by 14 government agencies

Appendix 13 – Detailed Comparison of Foreign Linkage Policies

	China	Japan	South Korea
policy reasoning	foreign technology transfers for “leap-frogging” unidirectional transfers, no long-term cooperation industrial espionage programme	foreign technology transfers to prevent “Galapagos effect” 1976-2016 limitations on international cooperation absorption through licenced production attempts for international collaboration	foreign technology transfers for gradual increase of sophistication domestic capacity to enable more valuable foreign partnerships compulsory offsets for technology transfers since 1987
1991 -2000	1989 sanction regime links to Russia, Israel and other non-Western partners gained importance technical and advisory consultations; off-the-shelf purchase and reverse engineering	1983 Exchange of Technology Agreement with US created exceptions to ban licensed production of US systems, preference to off-the-shelf acquisition increasing reluctance by US to allow transfers gradual switch to co-development	US most important partner since 1970s, licenced production when available 1992 offset ratio was reduced increasing relevance of technology transfer offsets, specifically to ADD 13 MoU signed
2001-2010	deepening cooperation with Russia exploitation of sanction loopholes; dual-use technology cooperation with European partners DIEG exchange with foreign universities in the US, Europe, Russia, Ukraine	2004 agreement on co-development of ballistic missile defence with the US	2006 DAPA takes over administration of the offset trade 12 MoUs signed
2011-2021	DIEG joint-laboratories with Western universities in dual-use technologies	2011 Statement on Guidelines for Overseas Transfer of Equipment – paved way for cooperation with other partners than US 2013 first cooperation agreement with UK 2014 Three Principles on Defence Equipment – de facto end to ban 2014-2021 18 agreements with 12 countries	offset banking system creating “offset credits” 2019 offset policy replaced by industrial cooperation programme gradual switch from technology transfers to improving share of domestic components in joint products 18 MoUs signed

Appendix 14 – Detailed Comparison of Financial Policies

	China	Japan	South Korea
overarching approach	nurturing policy		
policy tools 1990s	public R&D funding, public loans financial transfers, tax breaks, and low-interest loans budgetary independence for DIEGs (1998) dedicated R&D funds, 5% target for defence enterprise R&D	“Kokusanka projects”, dependable sole-source and sub-contracts spin-offs for civilian market cost-plus contracts for certain sectors, to expand profit margins “dual-use” R&D funding by MITI and other civilian organizations	Defence Industrial Promotion Fund reduced taxes and tariffs, low-interest loans, legal and administrative support, tax exemption on imported raw materials defence export promotion
policy tools 2000s	expansion of 863-programme 995-programme stock market listings, new capital sources (private) government guidance funds (GGFs) (2008)	-	2006 Defence Industrial Promotion Fund ends boost to defence export promotion
policy tools 2010s	additional capital sources (private) 2011-2016 additional funding programmes 2012/2013 GGFs are increased (SEI initiative) 2015/2016 GGFs are increased (Made in China 2025); dedicated MCF GGFs new overarching R&D funding plans (2019)	defence export promotion (2014 onwards) 2015 “Innovative Science & Technology Initiative for Security” programme, first dedicated defence R&D programme 2020 ATLA announces new funding tools for defence SMEs	further defence export promotion [ICMTC budget for bi-directional technology transfers (2014)]

Appendix 15 – Detailed Comparison of Acquisition Policies

	<i>Reform Foci</i>		<i>Policy Reforms and Changes</i>		
	1991 – 2021		1990s	2000s	2010s
China	competition, evaluation, supervision, transparency	creation of demand-pull system pricing reform	establishment of demand-pull system (1998) competitive bidding and market pricing systems for small acquisitions (1998) competition, evaluation, supervision (1998)	ex-post and ex-ante controls (pilot, 2009) multi-pricing methods (pilot, 2009)	expansion of 2009 pilot projects (2014) WEIAN platform for civilian, private suppliers (2015) single procurement entity (CMC EDD, 2016) expansion of flexible pricing
Japan		cost reduction, life-cycle management	increase of competitive contracts cost reduction, life-cycle management (1995) transparency and standardization (1998)	further increasing competition increased attention to transparency (2007)	long-term contracts transparency project management FMS rationalization comprehensive evaluation bidding system incentive system for cost reductions
South Korea		SME nurturing, risk reduction	gradual redesignation of items for competitive bidding auditing and inspections (1993) evaluation and life-cycle cost as factor for bidding (1996) transparency and information policy (1996) reserved contracts for SMEs (1996)	PPBEES streamlining end of designation system (2006) increasing domestic production (2008)	uni-resource, multi-supplier system (2016) reduction of liability clauses (2016) competitive contracts except for major projects “pursuit-type” R&D model project management fast-track, evolutionary acquisition models

Appendix 16 – Detailed Comparison of Human Resource Policies

	China	Japan	South Korea
HR Issues and Policies	overcapacity (1990s) downsizing (retirement, lay-offs, reorientation) lack of qualified personnel (1990s) university funding, direct recruitment 1998 Four Mechanisms (encouragement) lack of incentives market-based incentives and performance-related schemes better salaries, benefits, and career opportunities chief designer model problems 1998 /1999 modern programme management depoliticization and depersonalization of R&D system	loss of technicians in the defence sector (1995-2000); no policy response ban on recruitment of public officials by defence enterprises	civilianization of MND administration and DAPA
Domestic Talent Recruitment	COSTIND/SASTIND oversight of 29 educational facilities direct PLA recruitment at universities; 2500 recruitment centres (2019) 1995 increased university funding to increase graduate output “511” project to groom outstanding researchers and scientists 2015 Double First-Class University Plan; interlinked with MCF policy	direct recruitment at universities (JMoD/ATLA) “Recruitment Examination for Ministry of Defence Specialists” for internal R&D, procurement management recruitment for project management; special research officer system (2016)	direct recruitment at universities (MND) defence acquisition education system by KNDU, DAPA, ADD, DTAQ
Talent Recruitment Abroad	+200 general talent-recruitment programmes +600 overseas talent-recruitment stations Thousand Talents Programme (incl. 1000 Young-Talent Plan; Foreign Experts Programme) PLA, DIEGs, defence research actors directly recruit through programmes	-	