Technology transfer and defence sector dynamics

Sezal, Mustafa Ali; Giumelli, Francesco

Published in:
European Security

DOI:
10.1080/09662839.2022.2028277

European Security

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/feus20

Technology transfer and defence sector dynamics: the case of the Netherlands

Mustafa Ali Sezal & Francesco Giumelli

To cite this article: Mustafa Ali Sezal & Francesco Giumelli (2022) Technology transfer and defence sector dynamics: the case of the Netherlands, European Security, 31:4, 558-575, DOI: 10.1080/09662839.2022.2028277

To link to this article: https://doi.org/10.1080/09662839.2022.2028277

Published online: 01 Feb 2022.

EUROPEAN SECURITY
2022, VOL. 31, NO. 4, 558–575
https://doi.org/10.1080/09662839.2022.2028277

Technology transfer and defence sector dynamics: the case of the Netherlands

Mustafa Ali Sezal and Francesco Giumelli

Department of International Relations and International Organization, University of Groningen, Groningen, The Netherlands

ABSTRACT
State defence and security policies rely mostly on their military capabilities. The latter are ensured through research and development (R&D) as well as procurement, which are subject to defence industry dynamics. Furthermore the defence sector is heavily dependent on public funds; the latter can be more easily allocated if related R&D has a spill-over effect on the civilian sector, creating the potential for a bigger and more globally (or regionally) integrated market. This article investigates, then, how technology moves, and whether defence sector innovations create spin-offs in the civilian sector in the Netherlands. We aim to provide an industry-centred perspective on defence sector dynamics and potentials. For this, the article attempts to answer the following questions: Are defence technologies transferred to the civilian sector? What lessons can be derived from the Dutch case? To address these research puzzles the article's theoretical framework builds on the technology-transfer literature in analysing the case study of the Netherlands. The basis for this is 23 interviews with representatives of Dutch defence companies that were carried out both in a workshop and in one-to-one settings in May and June 2020.

ARTICLE HISTORY
Received 27 October 2021
Accepted 9 January 2022

KEYWORDS
Technology transfer; defence industry; spin-off; spin-in; dual-use

Introduction

The European security environment encompasses many different issues, from traditional threats such as territorial claims to newer ones such as cybersecurity. Since the St. Malo declaration of 1998, the European Union has undertaken a number of initiatives to avail itself of military capabilities, from rapid reaction forces to the most recent Permanent Structured Cooperation. While these initiatives have sought to enhance coordination between the existing military and security structures of the bloc's 27 member states, other undertakings have aimed to lay the foundations for joint military capabilities in the future. This has been done by the creation of a Europeanised defence industry via the public funding of joint research and development (R&D) projects, with stakeholders from different member states – above all the European Defence Fund.[1] These endeavours are implicitly based on the principle according to which public investment in defence

CONTACT Mustafa Ali Sezal m.a.sezal@rug.nl

sector R&D is believed to have a trickle-down effect on the civilian realm (Moretti *et al.* 2019). Technological innovations such as the Internet and duct tape, for instance, are often cited as examples validating this assumption. However this claim has actually been questioned in the literature, yet rarely tested in the European context at least.

This article intends to fill this gap by investigating the connection between the defence and civilian sectors. With this intent, we ask two core questions: Are defence technologies transferred to the civilian sector? What lessons can be derived from the Dutch case? With close analysis of the situation in the Netherlands, we find that the notion of a trickle-down effect from the defence sector to the civilian one is misplaced. In fact, this article argues that knowledge transfer is bidirectional and it in most cases runs rather from the civilian sector to the defence one. The latter's firms heavily rely on technological innovation developed by the civilian sector that can be applied to security and defence aims. Additionally, the evolving nature of security challenges has also contributed to the blurring of the lines between a purely defence sector and a purely civilian one. Instead, we posit that there are a growing number of "hybrid" companies that work in both the defence and civilian sectors and that, also as a consequence of this, defence innovation is driven by R&D done in the civilian sector. The case-study analysis shows that the classical distinction between civilian and defence sectors does not contribute much to our understanding of the industry in the Netherlands; integrated solutions based on civilian-developed information technology (IT) are at the core of the Dutch defence sector; and, with the triple helix model that is well-established within the country, the defence and security industries feed the needs of both the military-defence establishment and of the Dutch economy. As such, the article does not aim at contributing to the theoretical debate, instead it attempts to have a theoretically informed empirical contribution that partially confirms the theoretical literature.

The findings emerge from a case study of the Netherlands. Drawing from the literature on technology transfer and innovation, we explore the constitution and nature of the defence sector in this country (as representative of small actors in Europe, and also in a wider setting). The Dutch case is characterised by a rather open market and by small and medium-sized enterprises (SMEs). The analysis is based on a series of interviews done with 21 representatives from Dutch defence companies both in a workshop (Joint Effort for the Defence Industry, JEDI, Workshop) and in one-to-one settings in May and June 2020.

The article is divided into six sections. The first reviews the literature on technology transfer in general to establish the paper's theoretical basis. The second section then focuses on the defence sector and how it differs from other sectors, particularly regarding innovation and technology transfer. Before proceeding to the case study, we explain our chosen empirical research methods in the third section. The fourth section briefly introduces the Dutch defence industry, presents the setting at hand, and then continues with the results from our empirical research. The fifth section discusses the findings in relation to the technology-transfer literature as well as their wider implications. Finally, in the sixth section, the paper concludes with a brief summary of findings and by identifying avenues for further research.

How does technology move?

Technology transfer has been studied within and across many academic disciplines by now, including Economics, Management, Operational Research, (Industrial) Engineering, Sociology, Anthropology and Political Science. For understanding how the technology moves, it is imperative to tap into this interdisciplinary literature and explore central debates. While in the 1970s international technology transfer would gain prominence in the scholarship (i.e. Krugman 1979), from the 1980s onward increased interest was shown instead in domestic and cross-sector technology transfer as well as in public–private cooperation in innovation, technology development and technology transfer. Particularly the United States defence sector and market has been scrutinised in this regard. However, the defence sectors of other states have not been similarly extensively studied from this technology-transfer perspective. Therefore, we start with a general overview of the relevant parts of the literature and then focus on the defence sector and the Netherlands – as a representative case of small European states.

Innovation is considered the main driver of economic growth (Rosenberg 2004), although some recent expositions show that this might not always be the case (Maradana *et al*. 2017). In tandem, technology transfer is argued to be the main driver of innovation (Allen and O'Shea 2014). The latter is in essence the process whereby novelties are created, accepted and implemented. This makes the study of technology transfer an important task from Economics and Business Studies perspectives, as well as from others including Political Science too – because technology transfer refers to the "adoption of innovation" (Dubickis and Gaile-Sarkane 2015, p. 967). For this, defining "technology transfer" is imperative. According to Sazali *et al*. (2012a, p. 62) technology consists of "knowledge or technique" and "doing things". This is in accordance with the many definitions hereof, including the widely accepted one of Gibson and Smilor (1991, p. 290) whereby technology is seen as "knowledge or ideas as well as physical products". Although there are differing opinions, meanwhile, on what "transfer" specifically means (see discussion in Sazali *et al*. 2012b, 2012c), these are more about the dimensions or particular dynamics in play. Therefore, it would not be too much of a stretch to say that "technology transfer" is determined by the movement of the abovementioned elements between persons, groups and/or organisations. As such, it represents a process whereby new technologies (in other words, innovations) are transferred and adopted for other purposes such as further research, breaking fresh ground, or adaptation. Some (e.g. Botchie *et al*. 2018) differentiate between "hard" and "soft" technology transfers. Hard refers to physical components, soft to all nonphysical elements such as experience, skills, knowledge and organisation; the overall understanding remains the same, however.

In the private sector, innovation is tied to many different mechanisms that may or may not vary according to the specific subsector in question, kind of company involved and the like – but it also has similarities with the public sector as well (see, for example, Fuglsang and Pedersen 2011, Hartley 2013). What is worth mentioning is that publicly funded research has certain implications for both the private and public sectors. According to Moretti *et al*. (2019), increased government R&D spending results in increased private R&D too – although this does not imply efficiency. However, increased investment in R&D may result in spill-overs, particularly if one company comes up with a very innovative technology (Bloom *et al*. 2019). Separately, there has also been research done on the effect of government grants (Howell 2017, Azoulay *et al*. 2019), subsidies (Bronzini and Iachini 2014) and procurement on innovation (Slavtchev and Wiederhold 2016).

A broadened version of this scholarship, in fact, can be understood within the framework of the "national systems of innovation/national innovation systems" (NSI/NIS) initially put forward by Freeman (1987), and further developed by Lundvall (1992) and Nelson (1993). These national systems refer to institutions, policies and actors that influence knowledge production as well as the processes that adapt research to commercial or non-commercial applications and that affect whether an innovation is adopted by individual nations (Mowery 2009). This system comprises companies from different sectors that operate "within a common (national) 'knowledge infrastructure' and a common institutional and political framework" (Fagerberg *et al*. 2009, p. 432). In other words, NIS is an ecosystem in a given country that affects innovation including formal (such as institutions, R&D, procurement and similar) and informal elements (such as learning processes and unintentional technology transfers). Mayer and Blaas (2002) argue that well-developed and well-integrated NIS that foster technology transfer help small but open countries that are dominated by SMEs to compete on the world market and to technologically match larger economies.

A specific way to understand technology transfer, one that has received extensive focus in the literature and which requires particular attention here, is the university-industry version and especially the triple helix model of innovation wherein universities, government and industry collaborate (Etzkowitz and Leydesdorff 1999). According to this model, three components – namely university-industry, government-university and government-industry interactions – drive innovation. Recently, Miller *et al*. (2018) suggested the addition of another dimension called "societal based innovation users" to make it a quadruple helix. This adds a social dimension that involves local and regional dynamics as well. The triple/quadruple helix model has strong implications for the defence industry, where we see – particularly in the US, but also in the EU too – extensive collaboration between universities, government and industry. While the NIS is a general framework for studying innovation, the triple helix provides a specific model operating within that innovation system. Therefore, it can be seen as a deepening of the university-government-industry interrelationship within the NIS, thus enabling a more focused approach to be taken with regard to certain key empirical questions.[2]

When considering innovation and technology transfer, understanding the steps in the R&D and the production cycle is of the utmost importance. In this respect, different levels of development are categorised through a system called the "technology readiness level" (TRL) that starts with TRL 1 (basic research) and culminates in TRL 9 (manufacturable operational system).[3] Considering the TRL is essential to comprehend the level at which defence companies engage with technological innovations, and thus actual or potential technology transfers occurring at different levels and/or among organisations. Furthermore, TRLs allow us to identify when exactly companies, research and technology organisations (RTOs), and other public institutions get involved with innovation and begin interacting with one another. In other words, it is a crucial marker of the triple helix model and of levels of interactions occurring, that may indicate technology transfers taking place.

One way to trace technology transfer (or knowledge spill-over) is by looking at patents. Led by Trajtenberg (1990) as well as Jaffe *et al*. (1993), this involves turning to patent citations to see which emerging technologies are based on prior knowledge already patented. While this methodology provides a measurable tool to trace and analyse technology transfers, something that may not always be possible when only looking at networks or systems, its applicability to the defence sector is limited (as explained further below). The aforementioned frameworks and models aimed at dissecting and understanding the processes leading to innovation provide important insights on how technology transfer takes place. However, the defence industry has its own uniqueness as a sector.

Defence sector and technology transfer

While the definition of "defence" (and therefore "defence sector") is ambiguous today, a common understanding equates defence with military and external security as opposed to the homeland security that focuses on the domestic and civilian arena (Mawdsley 2011). As mentioned, the defence sector is a particularly interesting case if one seeks to discover how technologies move. Many civilian inventions such as commercial aerospace technology, the Internet, the global positioning system (GPS), lasers, digital imaging, microchips, drones, microwaves, superglue, duct tape and so forth have their roots in military-sanctioned research (DARPA 2018). These can be listed as notable spin-off technologies that were initially military/defence ones. It could be argued therefore that many "civilian" technologies widely used today are spin-offs. The Cold War is especially seen as the medium for many of these technologies being developed, applied and then marketed.

It has been claimed that four components enable spin-off processes: technological variety; knowledge exchange in terms of both spin-off and spin-in (meaning a civilian technology transferred to the defence realm); military functionality being similar to civilian needs; and, the tendency in defence projects to subcontract to SMEs usually civilian (Avadikyan *et al*. 2005). Spin-in is relatively more difficult to pinpoint; however, research on it has increased significantly in the last 15 years regardless. Acosta *et al*. (2020, p. 17) showed that the spin-in process (to the top defence firms) was "considerably less intense" than spin-offs. In their study, spin-off and spin-in processes are operationalised through the aforementioned patent citations that enable the researcher to follow the direction of the technology transfer. That being said, to some extent military equipment is developed or produced as a result of complex civilian inventions as well (Acosta *et al.* 2018). The methodological preference for focusing on patents has an important risk to it: the assumption that new technologies or inventions are immediately or eventually patented. However, it is highly possible that some companies opt not to patent their technologies. Therefore, we also need to keep in mind that complete data are not always available; particularly when analysing the defence sector, looking at patents may not be the most effective way to approach this problem. Furthermore, nowadays the R&D phase is conducted with the purpose of developing dual-use technology and the process thus takes the form of joint cooperation between defence and nondefence sectors rather than seeing directional transfers (Kulve and Smit 2003).

"Dual-use", however, is a somewhat ill-defined concept. It can also be regarded as a political distinction, particularly when considering export controls. One of the traditional understandings of the term states that a technology is dual-use if it is developed and used both by the defence/military sector and by the civilian one too (Cowan and Foray 1995). There seems to be a discrepancy in the way scholars understand and interpret the issue however: For example, as reviewed in Acosta *et al*. (2018), Wallin (2012) perceives that in some cases concepts of dual-use and spin-off overlap. One of the reasons for this is that definitions of dual-use do not emphasise having a sequential dimension, which means that even if the technology was developed for the defence sector the moment it is applicable in the civilian one it becomes a dual-use technology. Acosta *et al*. (2018) also adhere to this understanding, and therefore broaden the meaning of dual-use to include both spin-off and spin-in technologies while disregarding the sequential nature usually conveyed by the concept of technology transfer. According to Meunier and Zyla (2016, p. 92), the main reason for such moves is that "at the end of the 1980s, this spin-off paradigm seemed to run out of steam and the way of analysing technological similarity between the civilian and defence world evolved, thereby changing the perception of duality". Nevertheless, we keep the distinction here as our empirical sources use these terms separately (even if they overlap).[4]

When looking at the defence sector, technology transfer is mostly associated, as noted, with the experience of the US. Hence, the very common presumption ensues that technology is often transferred from the defence to civilian realm. However, it should be noted that there are different policies in the US (and EU countries) regarding military/defence research and development. This in turn results in very different experiences as well as mechanisms. For example, entities such as the Defense Advanced Research Projects Agency (DARPA) and mechanisms like "Cooperative Research and Development Agreements" in the US enable an organisational format there based on the triple helix model explained in the previous section. We can also observe this through the public-private technology-transfer lens that the model yields. The US Department of Defense has been known for sanctioning military research through DARPA since 1958. DARPA drives R&D and innovation by creating a scientific community with a presence in universities, the public sector and among corporations.[5] Funds are disbursed to a mix of university-based researchers, start-ups, established firms and consortia, but DARPA personnel are actively involved herein and reallocate sources or defund programmes when there is no progress. Furthermore, the Agency serves as a medium that links ideas, people and resources.

Ultimately, the main objective is innovation and developing new products. As such, the US government takes a hands-on approach where public sector officials work directly with firms and identify pathways for innovation (Mazzucato 2015). This specific model of public–private partnership in technological innovation is also a driver for technology transfers and dual-use technologies. As a result, publicly funded national laboratories and universities play a core role in developing new technologies for private companies mostly civilian in nature; this creates dynamism in the market. Similar mechanisms involving national research laboratories, universities and the private sector exist in individual EU member states such as Belgium, France, the Netherlands, Germany and Portugal as well (Merindol 2005, de France *et al*. 2016, Easton 2019, Simões *et al*. 2020).

Despite the fact that as a public we have been repeatedly exposed to the classical argument publicly funded R&D in the defence sector has a positive impact on "civilian" innovation, the NIS literature on defence R&D is not adamant about the validity of such an argument. According to Mowery (2009, 2010), there are three ways in which defence R&D and procurement influence other sectors and the general economy: (1) defence investments can lead to the development of NIS elements such as university-based research and education; (2) spin-offs; and, (3) procurement functioning as a "lead purchaser". However, it is also posited that the spin-off and procurement channels come into play when the technologies are rather new and the requirements of the civilian and defence sectors overlap and/or when defence constitutes the larger share of demand. Consequently, the influence of these channels declines as the technologies and/or the industries in question mature (Mowery 2009; 2010). This is also reflected in Meunier and Zyla's (2016) previously mentioned observation regarding the expanded sense of dual-use. Mowery (2009, 2010) contends, furthermore, that in certain areas such as IT, defence applications lag behind the civilian sector and technological spill-overs move rather from the latter to the former. The complex dynamics of technology transfer were also examined by Briones-Peñalver *et al*. (2020) in their study of the Spanish defence industry, where they identify a "dual transfer" process that highlights instances of mutual knowledge exchanges between defence and civilian sectors as a result of close collaborations between the two during the R&D stage.

Based on the literature review that has been provided here it is safe to say that there are several ways to categorise technology transfers. In terms of directionality, we refer to the basic classifications of spin-off (defence to civilian), spin-in (civilian to defence) and dual-use (a technology suitable for both sectors), respectively. However, as explained earlier, the situation is not always that straightforward. Civilian companies also apply for defence-related funds and operate partly in the latter industry, but do not call themselves as such regardless. This creates a peculiar complexity regarding previously clear-cut distinctions between the civilian and defence sectors. Furthermore, the mechanisms that drive technology transfer are influenced by the triple helix model of innovation and NIS, whereby RTO (and universities) also have a role to play. This sheds light on what the driving forces behind innovation and technology transfer are, doing so by looking at funding (public, private, or both) as well as at the different levels of R&D that may be conducted in different kinds of organisations. Finally, we must account for the fact that informal transfers also occur when people move between different companies and/or sectors, as they carry with them expert knowledge and relevant methodologies. This sort of transfer is, unfortunately, not easy to trace.

In the next section, we explain the methods used for this research. Following on, we then briefly cover the status of the defence industry in the Netherlands with a particular focus on how R&D is conducted there and what the potentials for technology transfer are. Finally, we delve into the empirical data that we collected via interviews with companies operating in the country's defence sector.

Methods

This article aims at exploring the nature and occurrence of technology transfer as well as its implications for the defence sector. The case study selected for this is that of the Netherlands, with the main reason being the structure of the country's defence industry. Unlike countries such as France, Germany and Italy that are home to a handful of large companies and original equipment manufacturers (OEMs) who drive their national defence industries, the Netherlands is characterised by its SME-driven sector. As such, it can be considered an illustrative case for small states (particularly in Europe) not in a position to lead, but who still represent crucial actors in being suppliers to larger companies in the global market.

The data collection for this research took place in two different phases. First, we organised the aforementioned JEDI Workshop with Dutch defence industry leaders and academic experts in October 2019. It was attended by 17 participants representing seven Dutch companies currently engaged with the country's defence and security sector (two companies were represented by two participants), six academic experts from the Universities of Groningen, Bologna and Södertörn, and a strategic analyst from the Hague Center for Strategic Studies. The eight Dutch companies were selected with the view to represent the market sector, so we invited small and larger companies as well as representatives from manufacturing (i.e. marine, aviation and small technological devices) and the service sector (i.e. law consultant and logistic). In order to complement the views offered by the selected companies, we also invited a representative from the *Nederlandse Industrie voor Defensie en Veiligheid* (NIDV – Dutch Industry Association for Defence and Security), which is the umbrella organisation that represents the whole Defence sector in the Netherlands. The objective of the meeting was to discuss the peculiarities of the Dutch defence industry in its own right as well as in the wider European context, processes of innovation and technology transfer, and the role of EU mechanisms with regard to the related market in the Netherlands (to be explored further in separate research).

The event was structured into two sessions. The first focused on how the defence industry was understood in the Dutch context and the potential for consolidation of this market at the EU level. The second session revolved around innovation as well as the technological, organisational, economic and legal-political factors that facilitate and/or inhibit technology transfer. The workshop was conducted under Chatham House rules, which enabled attendees to participate more freely; as a result, participants and their affiliations are not named.

The second phase of empirical work took place in 2020 meanwhile. While the Ministry of Defence (MoD) indicates that there are 350 industries in the defence sector, there were only 183 industries featured in the NIDV website. We contacted all of them via emails and via telephone at least four times. Eventually, we interviewed 11 representatives from 11 companies in the defence sector distinct from our erstwhile workshop participants (see appendix 1 and 2 for full interview list and appendix 3 for the list of questions). The semi-structured interviews took place in the Netherlands via video call, and were conducted under the condition of anonymity. In total, we have interviewed 10% of all companies featured by NIDV. We have interviewed any company that was willing to talk to us, therefore we acknowledge that a natural bias could exist in the sample. However, academic research based on interviews with companies from the defence sector fall within this range as there are various publications with comparable sample sizes, for instance with five (Calcara and Budrich, 2019), six (Calcara 2020) 15 (Calcara, 2017) and 26 (Haroche, 2020) interviews. As such, 21 semi-structured interviews with defence industries representatives supported by six academic experts and one strategic analyst represent a sufficiently broad empirical basis for the analysis.

In terms of data analysis, the article utilised process tracing (Bennet and Checkel 2015) based on the interviews to understand how and at what point the process of technology transfer occurs. Following the process of R&D, we were able to understand when and in what manner the technology transfer could be observed or had implications for the technologies discussed within the interviews. Then, our findings were evaluated in comparison to official strategy documents, reports and if possible the existing academic literature. In other words, we checked whether our understanding and categorisation fit the existing research. This methodology allowed three key dimensions to be studied. First, the pinpointing of the occurrence and the direction of technology transfers. Second, understanding the factors impeding and facilitating such transfers. Third and finally, a novel map of the European defence industry and market with respect to the empirical case of the Netherlands could be arrived at in aligning our own findings with the previous ones of the technology-transfer literature.

The practice of technology transfer in the Netherlands

The Netherlands is one of the founding members of both the North Atlantic Treaty Organization (NATO) and of the EU. As such, its strategic culture would assume both Atlanticist and European elements, particularly in the second half of the twentieth century (Noll and Moelker 2013). Despite being a small country, the Netherlands was in 1993 one of the first European ones to initiate a transformation and reform of its military in the new post-Cold War security environment by investing in light and modular forces as well as maritime-transport capacity (Knutsen 2017). Furthermore, its military is highly internationalised in the sense that it participates actively in joint international missions and has many strategic partners, cooperating closely on several key issue areas like shared military corps and training (Noll and Moelker 2013, Knutsen 2017). The Netherlands Defence Doctrine (Ministerie van Defensie 2019) stresses the role of the Dutch military, as defined by Article 90 of the Dutch Constitution, being "to promote the development of international legal order" and emphasises the importance and role of the military with respect to NATO and the EU.

In line with the Constitution and the Defence Doctrine, the Dutch MoD states that its overarching mission entails three main tasks: (1) protecting national territory, including the Caribbean part of the Kingdom of the Netherlands, and the territory of allies; (2) protecting and promoting the international legal order and stability and (3) supporting civil authorities with respect to law enforcement, disaster relief and humanitarian assistance, both nationally and internationally (Ministerie van Defensie 2018).

The country's defence sector is known as the Netherlands Defence and Security-Related Industry (NL-DSI). Traditionally, the NL-DSI has comprised SMEs mostly civilian in nature (van Oosterhout and Smit 1997, Dirksen 1998). Currently, the sector consists of "350 large and small companies with a joint turnover of EUR 4.5 billion. The sector employs 25,000 people, of whom almost 8,000 in research and development. The sector is responsible for approximately 0.7 percent of gross domestic product" (Ministerie van Defensie and Ministerie van Economische Zaken en Klimaat 2018). NL-DSI relies heavily on exports, with them amounting to up to 70 percent of companies' profit generators (JEDI Workshop Participant #11).

According to the 2018 Defence Industry Strategy document, the Dutch defence sector is active and prominent in a number of fields – such as maritime technology, ballistic missiles, systems integration, sensors, radar development, combat management systems and C4I (command, control, communications, computers and intelligence) capability.

However, the majority of companies working in the sector are SMEs. RTOs – namely NLR (*Nederlands Lucht- en Ruimtevaartcentrum*, National Aviation and Aerospace Laboratory), TNO (*Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk*, Netherlands Association for Applied Scientific Research) and MARIN (*Maritiem Research Instituut Nederland*, Maritime Research Institute Netherlands) – also play a very significant role in the Dutch defence industry. These organisations were originally established by the Dutch government to conduct defence, maritime and aerospace research. However, they are independent research institutions funded by both public and private means.

NIDV plays a prominent role in the country's defence sector. It is an industry association, one that represents the majority of companies making up the NL-DSI. Among other things, it also functions as a go-between for these companies and the MoD as well as the Ministry of Security and Justice. The Dutch Ministry of Economic Affairs and Climate Policy is another significant actor regarding the NL-DSI, one that sometimes finds itself at odds with the MoD (de France *et al*. 2016).

According to de France *et al*. (2016) as well as our interviewees, Damen Schelde Naval Shipbuilding is the only Dutch OEM within the NL-DSI. Other large companies operating in the Netherlands – and therefore considered part of the Dutch defence industry, such as Airbus, Iveco, Lockheed Martin, Rheinmetall and Thales – have parent companies abroad. Fokker used to be a Dutch OEM, but after its purchase by the British company GKN Ltd, it was restructured and no longer functions as an OEM.

In the Netherlands, TRL 1–2 are usually conducted by academic institutions. Depending on the technology at hand, TRL 3–8 can be conducted by NLR, TNO and MARIN. Herein companies can also participate, while the triple helix model of innovation and technology development is more commonplace too. The triple helix is also called the "golden triangle" in the Dutch context, denoting the crucial national importance of this model (Ministerie van Defensie and Ministerie van Economische Zaken en Klimaat 2018). If we refer back to the earlier-given definition of technology transfer as the movement of knowledge and/or adoption of innovation, this seems to be the main site where it happens. It is interesting that, according to van Oosterhout and Smit (1997, p. 169), the listed RTOs were once the only source of defence-related research taking place and "virtually no military research [was] carried out in Dutch universities". Today, however, defence-related basic research is also conducted at tertiary institutions such as the Delft University of Technology (interview #7).

Nevertheless, in principle certain companies are able to participate on their own in development at every TRL, while some focus on operating specifically at TRL 4–9. This depends on the technology that is being developed, as well as on the resources that the company in question has available to it. For instance, many SMEs cannot perform basic R&D at TRL 1–3 because this is an extremely capital-intensive process (interview #4).

One of our interviewees told us that their company, which focuses on maritime technology, was adept in R&D at TRL 3–7. This means they start with an experimental proof of concept and see it through to the manufacturing of an operational prototype. Since this company has been actively developing technologies on the basis of high levels of R&D, it was important to ask our interlocutor whether technology transfer was common. They stated that the latter was indeed a constant factor, and furthermore that it occurred in both directions (civilian to defence, defence to civilian) – albeit without giving any specific examples (interview #7). On the other hand, the majority of our interviewees from software companies – including one that engages at all TRLs – argued that technology transfers are usually unidirectional in the IT field, where it is from civilian to defence – therefore creating spin-ins rather than spin-offs (interviews #4, #5, #6, #10).

Additionally, one conversation partner stated that civilian software is sought out and then embedded in larger software developed for the defence market (interview #8). Another relayed that systems integration also relies on spin-in technologies (interview #1). Based on the responses and perspectives of various company representatives, it can be concluded that the direction of technology transfer is highly dependent on the defence subsector in question. That being said, the majority of SMEs seem to be more engaged with spin-in technologies than with spin-offs. This is explained by five factors derived from the responses we received: (1) civilian technologies are faster to the market and easier to integrate (interview #8); (2) a digital revolution has occurred in the civilian realm and the defence sector has been slow to keep up (interview #3); (3) R&D is conducted in the civilian sector as there is less capacity for such pursuits in the defence one (interviews #4, #5, #6, #10); (4) government clearance is costly to receive, and decision-making is slow (interviews #1, #6); (5) restrictions exist regarding spin-offs (interview #7). Dual-use technologies are also an essential feature of the Dutch defence and security industry. While for some companies technological innovations are always dual-use (interview #5), for others export controls constitute a substantial factor warranting caution (interview #7).

As explained in the second section of this article, one way to account for technology transfers – as the literature also points out extensively – is to look at intellectual property rights; in other words, patents (Acosta *et al*. 2013). Conversely, the interviewed company representatives stated that patenting their innovations is never a priority. This is because whenever a patent application is made, that technology becomes publicly available; if a company wants to keep its critical edge and market advantage then it refrains from such exposure.

Making sense of the unexpected: analysis of the results

We began this article by posing two core research questions: Are defence technologies transferred to the civilian sector? What lessons can be derived from the Dutch case? The data gathered and the discussion in the previous section provide us with very clear answers hereto, albeit ones somewhat unexpected. The first question resulted in responses that painted a very clear picture. It is a generic truth that defence technologies were transferred to the civilian sector during the Cold War years especially. However, the data collected shows that the occurrence of spin-offs is miniscule in the Netherlands. The only recent example we were provided with by interlocutors was the civilian application of a battery technology originally developed for military submarines (JEDI Workshop Participant #6).

Moreover, it was reiterated that if technology transfer was occurring then it would usually be from the civilian to the defence sector – particularly in the field of IT. On the one hand, this is at odds with the claim in the literature that spin-ins are rare (i.e. Avadikyan *et al*. 2005, Acosta *et al*. 2018, 2020) as well as with the common expectations vis-à-vis Cold War era technologies. On the other, it confirms the observations and expectations of the NIS approach to defence R&D that contends, "the technological spillovers that once flowed from defence-related technologies to civil applications now frequently move in the opposite direction" (Mowery 2009, p. 463).

The four components that enable spin-offs articulated by Avadikyan *et al*. (2005) were seemingly illustrated or at least reflected in the responses of our interviewees too. By combining these earlier-cited components with the five factors outlined at the end of the previous section, the outlook of the Dutch defence and security industry is revealed to be the following then: (1) technological variety seems to be present in the civilian sector (rather than the defence one), which is the result of the digital revolution that has happened therein; (2) knowledge exchange also occurs in the civilian realm, as R&D is conducted therein due to budget constraints in the military R&D ecosystem; (3) civilian technology is easier to integrate and market, a reversed understanding of military needs and civilian functionality; and, (4) subcontracts awarded to the civilian sector do not translate into spin-offs because government clearance is costly, decision-making is slow and usually there are related restrictions. As a result, companies opt to develop their own technologies and later adapt these to military needs if the demand arises. In any case, the triple helix model seems to be the most visible enabler of technology transfer, even if it does not speak to directionality. Both interviewees and the Dutch Defence Industry Strategy confirmed that this model works effectively in the Netherlands.

While more research needs to be conducted to better explain the aforementioned four-part outlook, our preliminary understanding is that the nature of the country's defence industry is very influential here. Since the Dutch defence sector mainly consists of SMEs and most of these companies do not consider themselves as exclusively defence-oriented ones, factors such as easier investment in civilian R&D and marketability seem to be core drivers. Furthermore, particularly with digital technologies it is easier for companies to provide custom solutions to defence buyers rather than vice versa. Finally, it can be argued that with the Dutch military reforming itself in the post-Cold War context, the country's defence industry simultaneously reshaped itself according to the former's needs as well as to a potentially internationalised market going forward. Today, cyber and integrated technologies seem to constitute the core of the Dutch defence industry; as such, technology moves from the civilian to the defence sector.

Consequently, we identify three main lessons from this research. First, defence is a very difficult concept to work with because the majority of (if not all) companies do not consider themselves defence ones. They rather think of themselves as civilian companies that also engage with defence- and security-related research. This means the classical distinction between the civilian and defence sectors does not contribute much to our understanding of the defence industry in the Netherlands per se.

Second, and relatedly, the contemporary defence/security/military industry can only be properly understood with respect to the role of hard and soft technologies. More concretely, apart from classical needs for weapons, ammunition, armoured vehicles and so forth, militaries and infrastructures now heavily depend on software too. Therefore, integrated solutions based on civilian-developed IT are at the core of the Dutch defence sector.

Third and finally, both strategic and business cultures are crucial elements herein too. In the Netherlands, internationalised SMEs constitute the core of the country's defence industry. With the by now well-established golden triangle or triple helix model, the defence and security industry feeds both the needs of the military-defence establishment as well as of the national economy.

Conclusion

State defence and security policies are made by governments but rely on their military capabilities. The latter are ensured through the national defence industry and related dynamics. We started this research with the premise that the defence sector is heavily dependent on public funds, and the latter are more easily allocated if R&D for defence has a spill-over effect on the civilian sector. Therefore, we asked two core questions: Are defence technologies transferred to the civilian sector? What lessons can be derived from the Dutch case? We expected to see that defence R&D would translate into civilian applications (spin-offs) and this would warrant more public funds being devoted to the former. Considering that the Dutch defence and security industry has in the last three decades become highly internationalised, this could lead to a regionally integrated market that may or may not become Europe- or EU-wide.

However, it has been shown that technology transfer mainly occurs as spin-ins, or from the civilian to the defence sector – particularly via the country's SMEs. As a result, we cannot claim that the current structure of the Dutch defence industry allows for spin-offs that would enable further integration in that sector. The current nature of the industry in the Netherlands is more suited to spin-ins, as R&D is conducted in the civilian sector and therefore more marketable as such. Although it is still possible to state that public funds do play a role in R&D processes, an increase in such funding is not to be expected based solely on the premise that it would facilitate innovation. As such the findings show that: the classical distinction between the civilian and defence sectors does not contribute much to our understanding of the Dutch defence industry; integrated solutions based on civilian-developed IT are at the core of the country's defence sector; and, with the well-established triple helix model, the country's defence and security industry feeds both the needs of the military-defence establishment and of the national economy.

The findings of this study are coherent with some literature on technology transfer, but it provides novel empirical material from a relevant case study of the Netherlands. New research can further extend the empirical foundation of our study in terms of number of companies and case studies. On the one hand, efforts should be made to seek an ideal sample representativeness of the market for defence and, on the other, the limited nature of spin-offs seems to be an important aspect requiring further investigation. Our findings also necessitate research conceptualising the differences between various parts of the EU and the role of public investments. Nevertheless, as a small country whose defence sector is dominated by SMEs and fairly export-oriented, the Dutch case provides important clues and expectations regarding other countries of similar nature elsewhere.

Notes

1. We use "defence" and "military" interchangeably throughout in referring to what is the same sector.
2. For a more detailed analysis of the relationship between NIS and the triple helix model, see: Sharif (2006); Leydesdorff and Zawdie (2010).
3. All TRLs with descriptions: 1 – basic principles observed; 2 – technology concept formed; 3 – experimental proof of concept; 4 – technology validated in lab; 5 – technology validated in relevant environment; 6 – technology demonstrated in relevant environment; 7 – system

prototype demonstration in operational environment; 8 – system complete and qualified; 9 – actual system proven in operational environment (EC Decision C(2014)4995).

4. A note on our approach to dual-use issues: It is logical to follow official definitions when dealing with national policies and strategies in the defence sector. As explored previously, dual-use can be a contested concept from an academic perspective. States, meanwhile, have a more rigid understanding hereof, as outlined in their export-control and strategic-goods regulations. That is not to say official definitions cannot be challenged; rather, it is to provide the right context for the analysis of technology transfer from/to the defence sector. For the Netherlands, EU Council Regulation (EC) No 428/2009 governs the export-control regime. Dual-use in the context of this document is defined as

   > items, including software and technology, which can be used for both civil and military purposes, and shall include all goods which can be used for both non- explosive uses and assisting in any way in the manufacture of nuclear weapons or other nuclear explosive devices. (Article 2(1))

5. For DARPA's role in the so-called personal computer revolution see: Fong (2001).

Acknowledgements

The authors thank the participants in the History and Theory of European Integration Colloquium at the University of Groningen and in the 2021 BISA European Security Working Group Workshop for commenting on a draft version of the article. We would also like to thank the editor of European Security and the anonymous reviewers for their invaluable comments that helped us to improve the article. All errors remain our own.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work is part of the Joint Effort for the Defence Industry (J.E.D.I.) Project funded by the European Investment Bank Institute under the EIB University Research Sponsorship (EIBURS) programme. The project is led by the University of Bologna, Italy and involves Södertörn Univesity, Sweden and University of Groningen, Netherlands.

ORCID

Mustafa Ali Sezal http://orcid.org/0000-0002-4252-0253
Francesco Giumelli https://orcid.org/0000-0002-5101-7254

References

Acosta, M., *et al.*, 2013. Factors affecting the diffusion of patented military technology in the field of weapons and ammunition. *Scientometrics*, 94 (1), 1–22.

Acosta, M., *et al.*, 2018. Patents and dual-use technology: an empirical study of the world's largest defence companies. *Defence and peace economics*, 29 (7), 821–839.

Acosta, M., *et al.*, 2020. Civil–military patents and technological knowledge flows into the leading defense firms. *Armed forces & society*, 46 (3), 454–474.

Allen, T.J., and O'Shea, R.P., 2014. Introduction. *In*: T. J. Allen and R. P. O'Shea, eds. *Building technology transfer within research universities: an entrepreneurial approach*. Cambridge: Cambridge University Press, 1–11.

Avadikyan, A., Cohendet, P., and Dupouët, O., 2005. A study of military innovation diffusion based on two case studies. *In*: P. Llerena and M. Matt, eds. *Innovation policy in a knowledge-based economy: theory and practice*. Berlin: Springer, 161–189.
Azoulay, P., *et al.*, 2019. Public R&D investments and private-sector patenting: evidence from NIH funding rules. *The review of economic studies*, 86 (1), 117–152.
Bennet, A., and Chekel, J.T., 2015. *Process tracing. from metaphor to analytical tool*. Cambridge: Cambridge University Press.
Bloom, N., Van Reenen, J., and Williams, H., 2019. A toolkit of policies to promote innovation. *Journal of economic perspectives*, 33 (3), 163–184.
Botchie, D., Sarpong, D., and Bi, J., 2018. A comparative study of appropriateness and mechanisms of hard and soft technologies transfer. *Technological forecasting and social change*, 131, 214–226.
Briones-Peñalver, A.J., Bernal-Conesa, J.A., and de Nieves Nieto, C., 2020. Knowledge and innovation management model. its influence on technology transfer and performance in Spanish Defence industry. *International entrepreneurship and management journal*, 16, 595–615.
Bronzini, R., and Iachini, E., 2014. Are incentives for R&D effective? Evidence from a regression discontinuity approach. *American economic journal: economic policy*, 6 (4), 100–134. doi:10.1257/pol.6.4.100.
Calcara, A., 2017. State–defence industry relations in the European context: French and UK interactions with the European Defence Agency. *European security*, 26 (4), 527–551.
Calcara, A., 2020. Cooperation and non cooperation in European defence procurement. *Journal of European integration*, 42 (6), 799–815.
Calcara, A., and Budrich, V.B., 2019. Differentiated integration in the European Defence. *European review of international studies*, 6 (2), 71–91.
Cowan, R., and Foray, D., 1995. Quandaries in the economics of dual technologies and spillovers from military to civilian research and development. *Research policy*, 24 (6), 851–868.
DARPA. 2018. *D60 - Defense advanced research projects agency: 1958-2018*. Tampa, FL: Faircount Media Group. Available from: https://www.darpa.mil/attachments/DARAPA60_publication-no-ads.pdf.
de France, O., Mampaey, L., and Zandee, D. 2016. Defence industrial policy in Belgium and the Netherlands. *ARES Group Policy Paper*. Available from: https://www.iris-france.org/wp-content/uploads/2016/10/Policy-Paper-Defence-Policy-Belgium-NL-October-2016.pdf.
Dirksen, E., 1998. The defence-industry interface: The Dutch approach. *Defence and Peace economics*, 9 (1–2), 83–97.
Dubickis, M., and Gaile-Sarkane, E., 2015. Perspectives on innovation and technology transfer. *Procedia – social and behavioral sciences*, 213, 965–970.
Easton, M., 2019. Reflections on the triple-helix as a vehicle to stimulate innovation in technology and security. *European law enforcement research bulletin*. Special Conference Edition Nr, 4, 35–45.
Etzkowitz, H., and Leydesdorff, L., 1999. The future location of research and technology transfer. *The journal of technology transfer*, 24 (2), 111–123.
Fagerberg, J., Mowery, D.C., and Verspagen, B., 2009. The evolution of Norway's national innovation system. *Science and public policy*, 36 (6), 431–444.
Fong, G.R., 2001. ARPA does windows: the Defense underpinning of the PC revolution. *Business and politics*, 3 (3), 213–237.
Freeman, C., 1987. *Technology, policy, and economic performance: lessons from Japan*. London: Pinter.
Fuglsang, L., and Pedersen, J.S., 2011. How common is public sector innovation and how similar is it to private sector innovation? *In*: V. Bekkers, J. Edelenbos, and B. Steijn, eds. *Innovation in the public sector*. Houndmills: Palgrave Macmillan, 44–60.
Gibson, D.V., and Smilor, R.W., 1991. Key variables in technology transfer: a field-study based empirical analysis. *Journal of engineering and technology management*, 8 (3–4), 287–312.
Haroche, P., 2020. Supranationalism strikes back: a neofunctionalist account of the European Defence Fund. *Journal of European public policy*, 27 (6), 853–872. doi:10.1080/13501763.2019.1609570.
Hartley, J., 2013. Public and private features of innovation. *In*: S. Osborne and L. Brown, eds. *Handbook of innovation in public services*. Cheltenham: Edward Elgar, 44–59.

Howell, S.T., 2017. Financing innovation: evidence from R&D grants. *American economic review*, 107 (4), 1136–1164.
Jaffe, A.B., Trajtenberg, M., and Henderson, R., 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. *The quarterly journal of economics*, 108 (3), 577–598.
Knutsen, B.O., 2017. Going deep! Acquiring new submarines in common? *Studia diplomatica*, 68 (4), 51–78.
Krugman, P., 1979. A model of innovation, technology transfer, and the world distribution of income. *Journal of political economy*, 87 (2), 253–266.
Leydesdorff, L., and Zawdie, G., 2010. The triple helix perspective of innovation systems. *Technology analysis & strategic management*, 22 (7), 789–804.
Lundvall, B., 1992. *National systems of innovation: towards a theory of innovation and interactive learning*. London: Pinter.
Maradana, R.P., *et al.*, 2017. Does innovation promote economic growth? Evidence from European countries. *Journal of innovation and entrepreneurship*, 6 (1), 1–23.
Mawdsley, J., 2011. Towards a merger of the European defence and security markets? *In*: A. J. K. Bailes and S. Depauw, eds. *The EU defence market: balancing effectiveness with responsibility*. Brussels: Flemish Peace Institute, 11–19.
Mayer, S., and Blaas, W., 2002. Technology transfer: an opportunity for small open economies. *Journal of technology transfer*, 27 (3), 175–289.
Mazzucato, M., 2015. *Entrepreneurial state: debunking public vs. private sector myths*. London: Anthem Press.
Merindol, V., 2005. Defense RDT&E and knowledge management: a new enquiry into public and public-private coordination. *Defense & security analysis*, 21 (2), 159–177.
Meunier, F., and Zyla, C., 2016. Firm growth and knowledge flows: comparative analysis between defence and civil areas. *Journal of innovation economics*, 20 (2), 89–108.
Miller, K., McAdam, R., and McAdam, M., 2018. A systematic literature review of university technology transfer from a quadruple helix perspective: toward a research agenda. *R&D management*, 48 (1), 7–24.
Ministerie van Defensie. 2018. *Defence White Paper*. Ministerie van Defensie. Available from: https://english.defensie.nl/downloads/policy-notes/2018/03/26/defence-white-paper.
Ministerie van Defensie. 2019. *Netherlands Defence Doctrine*. The Hague: Defence Staff. Available from: https://english.defensie.nl/binaries/defence/documents/publications/2019/06/27/netherlands-defence-doctrine/NDD_2019_English.pdf.
Ministerie van Defensie and Ministerie van Economische Zaken en Klimaat. 2018. Defence Industry Strategy. Ministerie van Algemene Zaken. Available from: https://www.government.nl/documents/reports/2018/11/30/defence-industry-strategy.
Moretti, E., Steinwender, C., and Van Reenen, J. 2019. The intellectual spoils of war? Defense R&D, productivity and international spillovers. *26483. NBER Working Paper*. National Bureau of Economic Research. https://doi.org/10.3386/w26483.
Mowery, D.C., 2009. National security and national innovation systems. *The journal of technology transfer*, 34 (5), 455–473.
Mowery, D.C., 2010. Military R&D and innovation. *In*: B. H. Hall and N. Rosenberg, eds. *Handbook of the economics of innovation*, Volume 2. Oxford: Elsevier, 1219–1256.
Nelson, R.R., 1993. *National innovation systems: a comparative analysis*. Oxford: Oxford University Press.
Noll, J., and Moelker, R., 2013. Netherlands. *In*: H. Biehl, B. Giegerich, and A. Jonas, eds. *Strategic cultures in Europe*. Wiesbaden: Springer Fachmedien, 255–268.
Rosenberg, N., 2004. Innovation and economic growth. In OECD. *Innovation and growth in tourism. OECD*, 43–52. doi:10.1787/9789264025028-4-en
Sharif, N., 2006. Emergence and development of the national innovation systems concept. *Research policy*, 35 (5), 745–766.
Simões, P.C., Moreira, A.C., and Mendes Dias, C., 2020. Portugal's changing defense industry: is the triple helix model of knowledge society replacing state leadership model? *Journal of open innovation: technology, market, and complexity*, 6 (4), 183.

Slavtchev, V., and Wiederhold, S., 2016. Does the technological content of government demand matter for private R&D? Evidence from US states. *American economic journal: macroeconomics*, 8 (2), 45–84.
Te Kulve, H., and Smit, W.A., 2003. Civilian–military co-operation strategies in developing new technologies. *Research policy*, 32 (6), 955–970.
Trajtenberg, M., 1990. A penny for your quotes: patent citations and the value of innovations. *The RAND journal of economics*, 21 (1), 172–187.
van Oosterhout, T., and Smit, W.A., 1997. The Netherlands. *In*: P. Gummett and J. A. Stein, eds. *European defence technology in transition*. Abingdon: Routledge, 167–195.
Wahab, S.A., Rose, R.C., and Osman, S.I.W., 2012a. Defining the concepts of technology and technology transfer: a literature analysis. *International business research*, 5 (1), 61–71.
Wahab S.A., Che Rose R., and Wati Osman S.I., 2012b. Exploring the technology transfer mechanisms by the multinational corporations: a literature review. *Asian Social science*, 8 (3), 142–150.
Wahab S.A., Rose R.C., and Osman S.I.W., 2012c. The theoretical perspectives underlying technology transfer: a literature review. *International journal of business and management*, 7 (2), 277–288.
Wallin, M.W., 2012. The bibliometric structure of spin-off literature. *Innovation*, 14 (2), 162–177.

Appendices

Appendix 1 – List of workshop participants – 21 October 2021

1. Dutch company A, NIDV member
2. Dutch company A, NIDV member
3. Dutch company B, NIDV member
4. Dutch company B, NIDV member
5. Dutch company C, NIDV member
6. Dutch company D, NIDV member
7. Dutch company E, NIDV member
8. Dutch company F, NIDV member
9. Dutch company G, NIDV member
10. Representative of the Nederlandse Industrie voor Defensie en Veiligheid (NIDV)
11. Expert from The Hague Center for Strategic Studies
12. Expert from the University of Bologna
13. Expert from Södertörn University
14. Expert from the University of Groningen
15. Expert from the University of Groningen
16. Expert from the University of Groningen
17. Expert from the University of Groningen

Appendix 2 – List of interviews

1. Dutch company, NIDV member, 12/05/2020
2. Dutch company, NIDV member, 20/05/2020
3. Dutch company, NIDV member, 28/05/2020
4. Dutch company, NIDV member, 02/06/2020
5. Dutch company, NIDV member, 03/06/2020
6. Dutch company, NIDV member, 05/06/2020
7. Dutch company, NIDV member, 08/06/2020
8. Dutch company, NIDV member, 09/06/2020
9. Dutch company, NIDV member, 12/06/2020
10. Dutch company, NIDV member, 15/06/2020
11. Dutch company, NIDV member, 29/06/2020

Appendix 3 – List of questions in interviews

1. How can we define the defence sector in the twenty-first century;
2. How does technology transfer occur in the defence sector and from the defence to the civilian sector;
3. What is the role of European institutions to foster intra-European cooperation in the defence industry.