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The defence industry as a locomotive for technological renewal in Russia: are the conditions in place?

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ABSTRACT

This article examines the extent to which the conditions for successful military to civilian technological spin-off are in place in Russia. This is important because Russian authorities use the potential for such spin-off as one of several arguments for justifying the large defence outlays. Six conditions are identified, all of which are derived from the theoretical literature on military to civilian spin-off. We conclude that despite some government efforts to generate spin-offs by providing technology brokering, and despite some joint military–civilian technological development taking place within defence industry enterprises, most of the conditions are only marginally present in Russia. AQ2

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Introduction

During the Cold War, many new technologies were first developed in the military field and then transferred to civilian use. The Internet, GPS and microwave ovens are but a few examples. However, in the wake of the 'information revolution', many Western experts in the field of defence economics came to think that most technology transfers would now occur in the opposite direction. As early as 1995, Robin Cowan and Dominique Foray argued that 'there is now a consensus that while military research and development may have been of value to the civilian sector in the past, this is no longer the case' (Cowan & Foray, 1995, p. 851). For the foreseeable future, these experts expected, the military would largely adapt technologies generated in the civilian sector of the economy. If this line of reasoning is accurate, it puts into question the expectation expressed by those in the Russian political leadership that the Russian defence industry (OPK) may function as an engine for the technological revitalisation of the country.[1]

President Vladimir Putin stated in 2015 that the defence industry should 'set the bar for technological and industrial development', and 'remain one of the main locomotives for innovation' (Putin, 2015). Russia wants to close the technological gap between itself and the other major powers. According to the Global Innovation Index, Russia was the 49th most innovative country in the world in 2015, with a score of 0.66 out of 1.0. Among the other

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major powers, the UK came second with a score of 0.99, the USA 5th with 0.97, Germany 12th with 0.92 and China 29th with 0.80 (Global Innovation Index, 2015).

Nevertheless, Cowan and Foray, as well as others, admit that under certain conditions, technology transfer from the military to the civilian spheres may still be of importance. Therefore, taking the current theoretical literature on military to civilian technological spin-offs as the point of departure, we have identified six such conditions that might facilitate technology transfer from the military to the civilian sphere. This will serve to structure the discussion of the Russian case, and enable us to identify those areas where the conditions are in place for successful military to civilian transfer of technology.

First, military to civilian technology transfer is more likely if the military research and development (R&D) contains a high degree of basic research (Cowan & Foray, 1995, p. 854). This may be the case either because the demands from the military require new insights from basic research, or because the military is willing to finance this kind of research even in cases where its immediate utility for new weapons systems is not obvious.

Second, the applicability of military technology for civilian use is likely to be higher in the experimental phases of new projects than in the single product development phase (Acosta, Coronado, & Marin, 2011; Cowan & Foray, 1995, p. 857). Thus, potential civilian users should be involved in these early phases rather than wait for final product designs to see what may be of use to them.

Third, as pointed out by Bellais and Guichard (2006), technology transfer is dependent on mutually satisfactory intellectual property rights. The military developer needs to feel secure that his products are not exploited for commercial use by others without due compensation, and the civilian taker of new technologies needs to know he can use this technology for civilian purposes without being met with restrictions on its use from the military developer.

Fourth, military to civilian technology transfer is more likely if there is a dedicated technology broker (Bessant & Rush, 1995; Molas-Gallart, 1997; Spinardi, 1992). Military and civilian producers often will not know about each other, and even if they do they may not know how to establish useful relationships. An institution with knowledgeable and experienced experts, who have as their specific task to look for military technologies with potential civilian applications, may go a long way towards easing this process.

Fifth, it is likely that more military to civilian technology transfer will take place when there are many enterprises that carry out military and civilian production at the same time. Here, there are possibilities both for direct transfers of specific pieces of hardware and second-order spill-over effects (Cowan & Foray, 1995, p. 862).

Finally, a high volume of military procurement may have a direct effect on civilian technology development if the defence firms as a result of this procurement order more and more advanced civilian goods (Mowery, 2012, p. 1711). It is likely that the military here in many cases will not only be satisfied with off-the-shelf models, but may commission civilian R&D projects.

These six points in no way negate the general claim that in the future more civilian technologies will be more likely to go to the military than the other way around. However, they do illustrate that given the right conditions there may also be a future for military to civilian technology transfers.

Another factor to consider here is the significance of the specific institutional environment in which Russian military and civilian R&D takes place. In this regard, Michael Porter has singled out competition as the most important motivating factor for companies to innovate, upgrade and thus survive in the long run (Porter, 1990). More empirical studies have also demonstrated a positive correlation between product market competition and productivity growth within a firm or industry (Blundell, Griffith, & van Reenen, 1995; Nickell, 1996). The neo-Schumpeterian growth model reconciles this evidence with general growth theory in that it delivers predictions that establish the role of competition and market structure, firm dynamics and the relationship between growth and development (Aghion, Akcigit, & Howitt, 2015; Aghion & Howitt, 2009). If competition is low – as it is in the Russian arms market with its mostly state-owned companies organised in huge conglomerates – the propensity to generate spin-offs and other innovative outcomes is likely to be low. AQ3

Finally, successful military to civilian spin-off will also depend on the demand for new technology in the civilian sector. This demand cannot be taken for granted. One study, in the area of nanotechnology, suggested that such demand is generally low in Russia (Connolly, 2013, p. 27). If the nanotechnology sector is indicative of the state of the industrial demand for high-technology products in general, than this suggests that even if the defence industry should have success in innovation, the potential for civilian commercialisation and mass production utilising the products of that innovation may still be limited.

The remainder of the article proceeds with a short description of the defence industry's place in the Russian economy. After that, we explore whether any of the six conditions presented above exist in the Russian economy today. A final section concludes.

The defence industry in the Russian economy

It is no coincidence that Russian leaders point to the defence industry when it comes to innovation. This industry occupies a significant place in the overall Russian economy, and much of Russian R&D takes place here. According to the defence industrial monitoring service, TS-VPK, in 2016, the industry consisted of 1367 enterprises and employed around 2 million people out of a total Russian labour force of 77 million (i.e. 2.6% of the labour force). An additional 10,000 companies took part in Russian defence production as sub-contractors (TS-VPK, 2016; World Bank, 2016).

Furthermore, not only does the defence industry constitute an important element of the overall Russian economy, it is especially important in the technology-intensive segments of the economy. According to a recent study, armaments currently constitute around 60% of Russian high-technology exports. The same study also claims that there is a strong historical tradition in Russia for seeing the defence industry as the 'core' of high-technology development and production (Koshovets & Ganichev, 2015, p. 121). Thus, Putin's statement that the defence industry should act as a locomotive for technological innovation is in the Russian context nothing new.

The role of basic research in Russian military R&D

In Russia there is no tradition for differentiating between military and civilian basic research. This means that there are no figures in official budgets describing exactly how much basic research is being carried out for military and civilian purposes. Nevertheless, at least four sources of basic research for military purposes may be identified. First, parts of the national budget chapter 'Fundamental Studies' fund basic research for military purposes. Second, a

Russian equivalent to the US Defence Advanced Research Project Agency (DARPA), the Foundation for Promising Studies, was established in 2013. Third, there is some funding for basic research, at least partly also for military needs, within the non-military Federal Target Programmes (FTsP).[2] And fourth, there is civilian commissioned research within the defence enterprises.

There is no specific budget chapter for basic research for military purposes in the official federal budget. This is in contrast to applied research and development, which has its own section in the national budget chapter 'National Defence'. Nevertheless, it is clear that at least parts of the national budget chapter 'Fundamental Studies' contain costs for basic research for military purposes in addition to civilian ones. The overall Russian federal expenditure on basic research is presented in Table 1.

By contrast, in the year 2015 alone, the costs in the sub-chapter 'Applied Research and Development' within the federal budget chapter 'National Defence' were 252.4 billion RUB (Minfin at http://minfin.ru/ru/perfomance/budget/federal_budget/budgeti/11-16/). That is, in 2015 Russia spent more than twice as much on *applied military R&D* as it did on all types of basic research combined.

Since 2013, most public expenditure on basic research has taken place within the FTsP Development of Science and Technology. The programme is supervised by the Ministry of Education and Science, and it contains the sub-programme 'Fundamental Scientific Studies' (see Table 1).

The difference that can be noted between the overall expenditure on basic research, as presented in the national budget chapter 'Fundamental Studies', and the state programme 'Fundamental Scientific Studies', is in the period 2013–2015 61 billion RUB, or about 17% of the total. These 17% are in general not used directly for scientific work as such. Instead, those expenditures are used for administrative costs and travel, etc. If we assume that these costs were about 20% also in the years 2011–2012, then the total finance of basic research in Russia, including funds from particular state grants, was about 400 billion RUB for the period 2011–2015.

The great majority of these funds were distributed to the different institutes of the Academy of Sciences (about 80% in 2011), and most of the rest went to different higher education facilities. Part of this research is likely to be basic research that also serves military purposes, but it is impossible to say exactly how much.

In 2014 the defence-oriented Foundation for Promising Studies had a budget of 3.3 billion RUB. The exact budget for 2015 was secret, but according to the Foundation's director, Andrei Grigorev, it would increase with an additional 1 billion RUB in 2015 with a further major increase expected in 2018 (RIA Novosti, 2014). Many of the Foundation's projects could

Table 1. Russian expenditure on basic research 2011–2015.

Year	National Budget Chapter Fundamental Studies	FTsP Development of Science and Technology, sub-programme Fundamental Scientific Studies
2011	85 billion RUB	
2012	83.2 billion RUB	
2013	102.8 billion RUB	83.6 billion RUB
2014	115.3 billion RUB	95.6 billion RUB
2015	127.7 billion RUB	105.8 billion RUB

Source: Russian Ministry of Finance, available at http://minfin.ru/ru/perfomance/budget/federal_budget/budgeti/11-16/

probably be described as basic research, but the overall size of the Foundation's funding is still negligible compared to the national budget chapter 'Fundamental Studies'.

There is probably also some financing of basic research for military needs in some of the other FTsPs. For example, the FTsP for the 'Development of the Aircraft Industry, 2013–2015' has a sub-programme called 'Aviation Science and Technology'. This latter sub-programme had a budget of 12.8 billion RUB in 2016.[3] Part of the research taking place within this sub-programme could probably be labelled basic research. This in particular concerns studies within aerodynamics and new materials. But, given the size of the overall state programme, the funding for these studies is not likely to be more than a few billion RUB.

A particular problem for the utilisation of findings from military basic research in the civilian industry is that relations between the Ministry of Defence and the Academy of Sciences have not been very well developed. A new framework agreement for cooperation was signed in September 2015, suggesting that this may change, but Defence Minister Sergei Shoigu said in this connection that the agreement would 'speed up the change from basic research to applied' (Shoigu, 2015). This statement indicates that the Ministry of Defence (MoD) would like the civilian Academy to take over as much responsibility for basic research as possible, leaving the MoD to concentrate its money on applied projects. Such a development would obviously reduce further the scope for spin-off effects from military research to civilian.

A final source of funding for basic research in the OPK is civilian commissioned research within the defence enterprises. Here, some clear data are available. In the years 2002–2012, between 20% and 30% of all research taking place within the OPK was on behalf of civilian customers, both government and private (TS-VPK, 2012). This structure of civilian versus defence orders within OPK research and development was relatively stable throughout the period.

Since financing for this research came from civilian sources, one might argue that it is not an indicator of how spending money on the defence sector may aid civilian technological development. On the other hand, one can also argue that the military, by maintaining and financing the enterprises that conduct this research, provides facilities and milieus of technological expertise accessible for civilian customers that otherwise would not have existed. Thus, when considering the extent to which government spending on the defence industry also may help civilian technological development, it seems reasonable to include also the research that OPK enterprises conduct on behalf of civilian customers.

The conclusion to this brief survey is that some basic research in support of military needs is taking place, and that some of that again may be of use also for the civilian industry. In particular, that may be the case in aviation. However, the exact size of that research in terms of money spent is difficult to quantify, and it seems largely dwarfed by the allocations to applied military R&D.

The role of civilian actors in the experimentation phase of new military technologies

The point in time at which potential civilian users get involved with defence companies regarding the development of new technologies may be very important for spin-off effects. In the early stages, both the military and civilian users may have a similar level of ignorance about the new technology and a common need to acquire knowledge. However, as pointed out by Cowan and Foray, as technologies develop 'military and civilian interests often diverge as the uses of each domain become more and more specialized' (Cowan & Foray, 1995, p. 857). Thus, spin-off for civilian use is more likely in the early than late phases of the development of a new type of technology.

Whether potential civilian users are likely to be present in the early stages is dependent both on the structural arrangements for military–civilian technology cooperation within any one country, and on the dominant traditions for military–civilian cooperation in technology development. The Soviet inheritance is not the most helpful for Russia in this respect. Several studies have demonstrated that the Soviet Union had a rather strictly 'military first' model, whereas, for example, Diatlov and Selishcheva show that both Germany and France at the same time had models of simultaneous development of military and civilian technologies (Cooper, 1991; Diatlov & Selishcheva, 2009, p. 11; Gaddy, 1996). This latter model made civilian early involvement substantially more likely. To give one example of the Soviet practice, Roman Gusarov argues that in the case of helicopters, the civilian ones were in Soviet times considered 'a pleasant side-effect' of military helicopter production (Gusarov, 2013). Since we know that only modest reform has taken place in the Russian defence industry, one may assume that these traditions at least to some extent have survived also today.

One example here may be the efforts to generate civilian spin-offs from research into Russian military Unmanned Aerial Vehicles (UAVs). This is officially recognised as an area where technology development can have both military and civilian use.

UAVs have long been considered one of the weak spots of the Russian defence industry (Makienko, 2011). At the same time, the Russian military has gradually come to see that this technology plays a vital role in modern armed forces. In addition, the Russian oil and gas industry came to realise that UAVs could be of great use also to them. In particular, the state oil and gas company *Gazprom* came to see their utility for the monitoring of gas pipelines. *Gazprom* has so far monitored its pipelines mostly with helicopters. For this reason, the oil and gas technology company, *NefteGazAeroKosmos,* and its head, E. M. Eremin, approached relevant OPK factories in order to engage in a mutually beneficial early phase joint military and civilian development of UAV technologies. Eremin found, however, that the technological solutions the Russian OPK companies were pursuing at the time were very different from what *Gazprom* and other oil and gas companies needed. Furthermore, the OPK companies demonstrated minimal flexibility when approached. According to Eremin, his own

> investigations demonstrated a major technological gap between the OPK and the oil and gas industry, [an] enormous lack of agreement between different OPK companies and their enmity towards smaller (read civilian) business companies, all this preventing the successful use of OPK innovations in the development and purchase of modern domestic technology for use in the oil and gas industry (Eremin, 2008).

At least in this case, the suggestion to have civilian actors present in the experimentation phase of new military technologies met with very little enthusiasm on the OPK side.

Another example is the Russian helicopter industry. Here, long term state contracts in the state armaments programme have led to a substantial boost for the industry. Nevertheless, there are few signs that this will lead to significant civilian spin-offs. The large state and export orders for medium and heavy military helicopters mean that the industry is likely to do well for many years without production for the civilian market. This is the case even if the financial situation within the branch suggests that now would be the time to boost civilian development in preparation for smaller military orders in the future. President Putin in 2013 explicitly warned the OPK that sometime after 2020 there would be less money for military orders, and that they therefore now should get ready to produce 'goods for the civilian market, both at home and abroad' (Nikolskii, 2013).

UAVs and helicopters are only two areas of technology development, and it may well be that defence and civilian developers are closer in the initial stages in some of the other branches. For example, there seems to be a fruitful cooperation between the largely military aircraft engine producer *Saliut* and the civilian Institute of Structural Macrokinetics and Materials Science. They are jointly developing new materials that can solve problems in both military and civilian aircraft engine construction simultaneously (Boikova, Gavrilov, & Gavrilicheva, 2009, p. 12).

One organisational step that Russia could take in order to involve civilian interests more at an early stage would be to take into account civilian priorities when developing the document entitled 'Main Directions in the Development of the Armaments, Military, and Special Equipment' (*Osnovnye napravleniia razvitiia vooruzheniia voennoi i spetsialnoi tekhniki*). The document is part of the state armaments programme, and points out the main priorities in military R&D for the next 10 years. As of today, only the expected requirements of the armed forces and major international trends in military technology development influence the content of this document (Kashin, 2014, p. 12).

Intellectual property rights

A decade ago, Bellais and Guichard (2006, p. 285) concluded that many intellectual property laws did not 'fit technology transfer from the government-funded, secrecy-based defence R&D to the privately-funded, patent-based civilian industry'. They were referring to Western countries, but the same is probably to a large extent true also in Russia. According to Bunevich and Petrov (2013, p. 77), OPK companies generally lack both a carefully considered patent and licensing policy, and trained personnel especially dedicated to the protection of intellectual property rights. Boris Kuzyk, a central figure in the post-Soviet Russian OPK, points to the problem of intellectual property rights as one of the most important impediments to generating military–civilian spin-offs (Kuzyk & Iakovets, 2005, p. 9). Bunevich and Petrov (2013) indicate that the inexperience of the OPK with the protection of intellectual property rights in several cases led these enterprises to conclude contracts with civilian customers that were very disadvantageous to themselves. This experience may discourage them from trying the same again.

Furthermore, this problem may be more severe in Russia than in many Western countries because the intellectual property rights regime itself is so weak. In 2014 Russia scored 5.1 on the International Intellectual Property Rights index, where the maximum score is 10. By comparison, China scored 5.4, India 5.5 and the USA 8.4 (Intellectual Property Rights Index, 2014). Thus, in addition to the fact that the intellectual property rights regime in the OPK is weak, the respect and understanding for intellectual property rights in general is feeble in Russia.

The state of affairs described above will probably not be helped by the 2012 Government decree No. 233, which assigned intellectual property rights for technologies developed under the State Defence Order (GOZ) to the MOD as well as the developer (Falichev, 2015). Thus, the intellectual rights to new military technologies are even more unclear than before, and at least one of the patent holders, the MoD, has priorities that have little to do with spin-off possibilities. The MoD's main priority is often to prevent copying by foreign powers or illegal technology exports. Furthermore, the MoD may also be concerned that the early release of new military technologies for civilian use may reveal too much about the state of technological development within specific military branches. If that is the case, they may for example demand that patents are delayed for a specific period of time before being released to civilian users. Both of these considerations may make the MoD reluctant to release new technologies for civilian use.

Technology brokering and technology transfer

The rationale behind technology brokering is to bridge the gap between research and development and commercial markets. For the purpose of this article, technology brokers are regarded as 'organisations charged with identifying technologies with dual-use potential, typically emerging from military research efforts, and marketing them to clients' (Molas-Gallart, 1997, p. 378).

In principle, a technology broker might be a specialised external entity as well as an internally led department for commercialisation. It might also consist of some informal mechanism (Molas-Gallart, 1997, pp. 379–380). The one aspect of technology brokering discussed in this article pertains solely to transfers from a defence company assisted by a formal external or internal broker to an unconnected civilian company. Transfers between specific military and civilian divisions within the same company are discussed in the next section.

In the Russian context, several types of actors correspond to one or more of the above mentioned features of a technology broker. Some examples are given below in order to show the variety of organisations, their targets and networks. However, as data on the subject are scarce and hard to find, we rely on sources where the quality of information is not uniform. The reader is therefore advised not to consider this compilation as exhaustive or as perfectly representative for all Russian technology brokers.

The Russian Technology Transfer Network (RTTN) was set up in 2002 with EC-TACIS support as an umbrella organisation to facilitate coordination between different research institutes regarding technology transfer. In 2003 the first centres of a regional technology network were established in Russia based on the institutes of the Russian Academy of Sciences, research departments at well-renowned universities or other scientific centres of federal significance. In 2006 there were already more than 70 centres. These centres have a strictly counselling role. They ensure commercialisation of publicly-funded R&D, handle licensing agreements and provide legal assistance regarding, for instance, protection of intellectual property (Lushchekina, 2006). Neither the RTTN nor the technology transfer centres as a group specialise in technology transfers from the defence industry to the civilian market as such.

Another more recent example is the 'North-West Inter-University Centre of Science, Education and Technology for the Interests of the Military–Industrial Complex', which was established as late as September 2014 at the Saint Petersburg Electro-technical University (LETI) in cooperation with the ITMO University[4] and Saint Petersburg Polytechnic University. The centre's main tasks are related to R&D on behalf of the domestic defence industry and establishment of technological clusters between the defence industry and academic research. The centre is also set to develop proposals for the transfer and adaptation of military technology and research results to the civilian sector of the economy (Saint Petersburg

Electrotechnical University, 2014). Given the short time frame since the establishment of the centre, little is known about its present activities and achievements. Given the complexity of technology brokering, it is also questionable whether an academic institution can provide the necessary skills and competence.

Due to its financial strength and state support, the most interesting actor in the field of military technology brokering in Russia today is probably the 'Civil Technologies Fund', established in late February 2013.[5] Its main shareholder is the Russian Venture Company, or RVC, which owns 70% of the fund. The RVC in turn is a government fund of funds, and a development institute under the Russian Federal Agency for State Property Management, a subdivision of the Ministry of Economic Development and Trade. As such, it is one of Russia's key tools to build a well-functioning national innovation system.

The two other holders in the Civil Technologies Fund, the less known 'Science, Technology and Innovation Development Fund' and the 'Ramenskoe Design Company' hold 10% and 30% shares respectively. Their role in the Civil Technologies Fund is less clear, but might give the fund more exposure to the city of Ramenskoe where both are registered, or towards the aircraft industry, as the Ramenskoe Design Company manufactures navigation equipment and systems for military and civilian fixed-wing aircraft and helicopters (RVC, 2013, 2014).

The initial duration of the Civil Technologies Fund has been set to seven years, and its purpose is to commercialise civil technologies from highly competitive Russian companies, including defence companies. Another objective is to provide seed capital to start-up enterprises working with critically vital technologies regarding high-tech tool making, microelectronics and special-purpose micromechanics, visualisation, precision navigation, new materials, integrated systems and different kinds of advanced heat treatment technology.

During its first year of existence, the Fund co-financed three projects with a total of 108 million RUB after examining 170 propositions. The first, Makstelkom, is a universal welding machine for ultra-reliable fibre-optic communication systems. The second is Transcoder, a new generation video transcoder with possible cloud acceleration. The last project, Racer, aims to develop and launch an affordable hybrid media player adapted for the HEVC/H.265 video compression standard (RVC, 2013, 2014).

During its second year of operations, the fund planned to expand the investment portfolio to six companies. However, according to the fund's stakeholders, the significance of Civil Technologies goes beyond the specific projects in which it participates. Allegedly, it has also had a positive effect on the business activities of industrial enterprises as well as an improved preparedness for product commercialisation (RVC, 2013, 2014).

Yet, given that the fund disposes over 1.5 billion RUB, the investment rate needs to be significantly increased in order to put this money into work before the present time limit for the fund expires. If the three projects already in the portfolio can be viewed as any guide, the fund is positioned to finance some 40 projects. Another issue is how much the Russian state really prioritises technology transfer from the military to the civilian sector based on technology brokering. So far, the Civil Technologies Fund represents less than 6% of the total investment capital that RVC disposes (RVC, 2015).

Civilian production within the defence industry

Far from all defence companies are solely dedicated to military or defence-related production, and extensive civilian production within the defence industry is a factor that in a Western context increases the probability that technology transfers and spill-overs will take place. These transfers are not only related to direct transfers of specific pieces of hardware to commercial applications but to second-order spill-over effects as well, such as incorporation of results from military-based R&D into improved civilian products and processes. For instance, Cowan and Foray argue that a relative similarity in the practices of civilian and military innovation management during the 1950s made exploitation of economies of scope possible within companies pursuing both military and civilian R&D programmes. As long as military technology was more advanced than civilian technology, defence R&D was highly relevant to commercial industry (Cowan & Foray, 1995, p. 854).

Another spill-over effect at work in defence companies with a large share of civilian production is the organisational effect. Military R&D generates a critical mass of scientists and engineers who might be used to take on civilian projects as well (Cowan & Foray, 1995, pp. 861–862). Principles of management, such as quality control, might also diffuse from the section assuming military projects to the rest of the company (Cowan & Foray, 1995, p. 854).

The presence of civilian and military production in the same company, however, is no guarantee for technology transfer or spill-over effects actually taking place. One reason is that the generic similarity of civilian and military technologies has declined over time. In other cases current civilian R&D might be more advanced than military R&D (Cowan & Foray, 1995, p. 854).

Several objections to the organisational effect have also been put forward. These are based on the frequent lack of relative similarity between military and civilian R&D in the practices of innovation management. The military cost–performance trade-off prioritises technological sophistication and performance to civilian quest for cost effectiveness. There is a risk that 'military R&D programs may encourage "learning" of expensive and ultimately inefficient habits, for example, a predisposition to substitute large-scale experimentation and computation to rigorous thought' (Mowery & Rosenberg, 1989). Companies might therefore try to avoid cross-fertilisation between military and civilian R&D (Cowan & Foray, 1995, p. 855). Another incentive to keep research departments apart is a lack of organisational compatibility between military and civilian operations based on, for instance, key differences in procurement practices, regulations and government accounting rules (Watkins, 1990, p. 397). Diversification is also comparatively easier for smaller companies operating upstream in the defence markets as producers of components and sub-systems (Molas-Gallart, 1997, p. 373). AQ4

In the Soviet system, the Russian defence industry had a substantial civilian side. In 1991, Soviet defence industries produced, for instance, a third of all rail freight wagons, over 80% of the tramcars and a very high proportion of electrical and electronic consumer goods, household appliances, vacuum cleaners and so on. Characteristically, civilian production was carried out in relatively separate factories or production shops, although some of it involved so-called assimilation production, where the same equipment and manpower was used for making civilian and military components. It was estimated at the time that about 40% of the output of the defence industrial complex was civilian and about one-third of R&D undertaken in the defence industry was of a civilian character (Cooper, 1991, p. 33). However, civilian production plummeted after 1991 due to weak domestic demand for civilian goods, lack of market experience and a military cost performance structure, which had been furthermore enhanced by the Soviet command economy (Cooper, 1991, p. 39; Kennaway, 1993). In short, Russia failed to build a civilian economic locomotive based on the conversion of the military industry. In 2014 the civilian share of the output of the defence industry had shrunk to less than 21% (Riazantsev, 2015).

After some experiments with private ownership during the early 1990s, the Russian defence industry consolidated as a mostly state-owned or state-controlled industrial sector. The biggest state defence industrial conglomerate that evolved in this system was *Rostekhnologii*, which markets itself under the brand name *Rostec* since 2013.[6] According to the 2014 annual report (Rostec, 2015a), its total revenue amounted to 964.5 billion RUB, which was equivalent to 1.35% of Russian GDP. The corporation counted some 700 entities, of which 292 were directly or indirectly involved in the state armaments programme (Rostec, 2015b).

The Rostec Corporation is thus a major actor in the Russian defence industrial complex (Malmlöf, Roffey, & Vendil Pallin, 2013, p. 123). It is furthermore an important actor on civilian markets as well, as 28% of its production is of civilian character (Rostec, 2015a, p. 33). Presumably, a sizeable part of all technological transfers from the military to the civilian sector in Russia ought to take place within Rostec. For that reason it is one of only a few companies whose potential technology transfer from its military to civilian sectors ought to have a recordable impact on Russian economic growth per se.

Rostec markets itself as a technology-driven organisation, with innovation and technology at its forefront. In 2014, the share of innovative production amounted to 24% of total production (Rostec, 2015a). It also takes active part, for instance, in the preparation and establishment of the usually quadrennial *List of Critical Technologies of the Russian Federation* – one of the main state policy instruments for Russian science and technology development. The bulk of Rostec R&D activities are related to arms and defence systems. Still, its subsidiaries have developed some noteworthy civilian innovative products. One of the products already for sale, for instance, is the lung ventilator system Aventa-M (*Kret*, 2014).

Rostec has taken several measures promoting innovation in later years. Its 'Innovation Strategy for 2011–2020' aims to strengthen and develop its innovation infrastructure (Rostekhnologii, 2011a, 2011b). The innovation strategy does not explicitly address technology transfers between its civilian and military entities. Although the more recent Development Strategy identifies the need to develop instruments for R&D transfers between the civilian and military spheres as a prioritised area for Rostec's innovation policies, this theme is not further elaborated (Rostec, 2013, p. 25). Joint military and civilian production within the same entity or holding company does therefore not seem to be a strong feature of Rostec official corporation policy, even if it cannot be ruled out that it takes place.

Civil subcontracting to the defence industry

Technology transfer and spin-off effects from the military to the civilian sector also occur when civilian subcontracting to the defence industry is conditional on further civilian R&D or adaptation rather than on straight purchases off-the-shelf. A civilian subcontractor distinguishes itself from a company or research entity with in-house civilian and military production in that it is basically civilian to its character and operates from outside the defence industrial sector.

From the civilian subcontractor's perspective, the size and anticipated development of the military share of its total backlog is a critical factor for its willingness to adapt production to military needs, norms and standards (Cowan & Foray, 1995, p. 855). Another issue of strategic importance to the subcontractor is the existence of any possible civil application and potential market for the technology or upgraded military product. A constraint in this regard is that civilian spin-off benefits from defence-related R&D and procurement on innovation within a given technology often declines as the technology or the supplier industry matures (Mowery, 2012, p. 1713).

Government procurement policy might also affect the nature and scale to which defence-related R&D produces advances in civilian technologies. Small procurement budgets tend to channel military demand to monopolistic suppliers that face little pressure to explore opportunities in civilian markets. On the contrary, if the procurement budget allows for enhanced competition among several firms, this might be a powerful incentive to develop a new approach to civilian market segments as well. Another strategy to enable knowledge and technology transfer among several firms is to pursue a policy of second source production. Compliance with second source requirements means that firms have to exchange design and process knowledge with other firms in order to ensure that there is a second supplier able to produce an identical product in order to avoid supply interruptions (Mowery, 2012, p. 1713).

A noteworthy Russian case in point regarding civilian subcontracting to the defence industry relates to Russia's domestic machine tool industry. At its core, this is a civilian industry that supplies machine tools to all kinds of engineering industries. Yet most of its customers are defence-oriented. It is therefore conceivable that the machine tool industry is potentially receptive to military demands, which, in the end, even its civilian customers might profit from.

However, the Russian market for domestic machine tools currently suffers from a serious mismatch between customers' needs and the supply. The industry consists of approximately 100 companies, of which most are in a bad condition after decades of neglect and misdirected economic policies. Because of the technological and organisational backwardness of Russian machine tool manufacturers, the Russian defence industry prefers to rely on foreign-made machine tools, illustrated by the fact that up to 90% of industry demand for machine tools is currently covered by imports (Russian Government, 2013).

However, the Russian leadership considers the machine tool industry to be of strategic value for the modernisation of the defence industry, and ultimately, for the fulfilment of the state armament programme. In 2013 Russia's Minister of Industry and Trade, Denis Manturov, maintained that the value of public procurement of industrial machinery until 2020 would amount to 150–200 billion RUB, of which 80% were earmarked for the needs of the defence industry (Evstigneeva, 2013).

One of the instruments that the state uses to support the machine tool industry is a special development programme that runs from 2011 to 2016. It was first included as a sub-programme to a federal target programme for the development of the national industrial base for the years 2007–2011.[7] In 2013 a special holding company for the machine tool sector, *Stankoprom*, was also set up under the management of the state-owned defence industrial concern Rostec.

This approach has been severely criticised not least by private machine tool manufacturers. Allegedly, the present state strategy does not address the inflexible Soviet-style industrial model based on large companies with extensive in-house production. On the contrary, it guarantees that the system with mega-companies will remain intact. It also brings about a top-down strategy towards the developmental needs of the machine tool industry, as the

Ministry of Industry and Trade has been assigned the role of intermediary between the machine tool industry and the engineering industries. It is the ministry that determines and finances the direction of R&D aimed at machine tool development, settles what machines are to be produced and bankrolls their production. The traditional machine tool industries also expect that the state settles quotas for domestic machine tools as well as preferential prices in order to guarantee a steady demand and a payback time between five and a maximum of eight years. Hence, this industry is more or less protected from that customer-centred approach that is needed to create a functional market based on specific knowledge about actual needs and demand. In essence, the traditional machine tool companies ostensibly want the state to organise demand for those products they know how to produce but that no one really needs (Krasnova, 2014; Mekhanik, 2014).

Given the present policies aimed at the machine tool industry, Russia has thus disregarded the constructive impact that military demand on dual-use technologies might have on civilian products based on the same technologies. The same is true for the radio electronic industry, which is another very central industrial sector for the state armament programme. The most crucial electronic companies were incorporated in a state holding structure – Ruselectronics – already in 1997. In 2009 it was reorganised and transferred to Rostec (Ruselectronics, 2015). Furthermore, the most recent federal target programmes for the electronics industry – drawn up for the periods 2008–2015 and 2013–2025 – look a lot like the development programmes for the machine tool industry.[8] First, there is preponderance towards defence-related and military electronics. Second, it is the Ministry of Industry and Trade that determines and finances R&D and establishes demand based on its role as the industry's main customer through the State Armament Programme (*Federalnaia tselevaia programma*, 2007–2011; Khokhlov, 2015).

At least for these two examples, it seems that the Russian preference for large-scale and the Soviet-era penchant for centralised plans and programmes is still far too strong to take advantage of a more independent civil industry capable of adopting to military needs and to transfer these needs to the civilian economy.

Conclusions

Based on the evidence analysed in this article, no unambiguous answer can be given to the question of whether the preconditions are in place in Russia for the defence industry to become a locomotive for technological renewal of the country. Our best estimate would be that the large defence orders indeed will bring some technological renewal to parts of the civilian industry, but that unless the preconditions become much more firmly founded than they are today, the combined effect will fall very short of the national technological renewal that senior officials hope for.

The exact amount of basic research as a part of total military research and development cannot be definitely established. Still, the fact that there is a national budget chapter called Fundamental Studies and that the Foundation for Promising Studies was established in 2013, do demonstrate government attention to the issue. On the other hand, the statement by Defence Minister Shoigu, where he suggested that basic studies is first and foremost a civilian task, indicate that the share of basic research within total military research and development is at least not likely to increase.

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The Soviet tradition was to keep military and civilian research relatively separate. Furthermore, within the defence industry, technological solutions for the civilian industry were seen as lucky side effects. Our examples suggest that this attitude is still strong within the Russian defence industry, and that this is preventing cooperation between military and civilian actors in the experimentation phase of new technologies. There seems to be a path dependent harmful tradition here.

On the question of intellectual property rights, Russia has two main problems. First, these rights are by international comparison generally very weak, and particularly so within the defence industry. Second, the 2012 decision to share these rights between the developer and the MoD may further have increased the problem. The MoD is generally more concerned with preventing copying by foreign powers or illegal technology exports than with making military technologies commercially available.

The situation seems to be slightly better in the area of technology brokering. There is both an umbrella Russian Technology Transfer Network and more branch specific actors which try to combine the technological interests of the defence industry and the oil and gas sector. There are also regional initiatives. In addition, the most promising institution may be the Civil Technologies Fund, which is specifically designed to commercialise new technologies from the most competitive Russian companies, including defence enterprises. Most of these structures, however, are relatively new, and it is therefore premature to give a verdict on how well they function.

Both in Soviet and post-Soviet times there has been a strong tradition for civilian production in defence plants. This should aid military to civilian spin-off both in terms of direct technology transfers and second-order spill-over effects. However, civilian production on defence plants has decreased throughout the post-Soviet period. The conglomerate Rostec, which alone produces 26% of the yearly state defence order, does indeed combine a lot of military and civilian production, but our short analysis of the company does not suggest that military to civilian spin-off is a major priority. Co-location is by itself no guarantee for spin-off.

In terms of civilian subcontracting to the defence industry, our examples from the Russian machine tool and electronics industries are not encouraging. There are few working horizontal ties between the machine tool building industry and the OPK, and the state, to the extent that it tries to intermediate, often seems neither very knowledgeable nor very efficient. Despite serious state support for this industry, military producers tend to buy machine tools abroad. If they instead had given the orders to the domestic civilian industry, that in its turn could have sparked development of new technologies on some civilian plants.

Our most general conclusion is that the Russian government has placed significant political focus on the issue of military to civilian spin-off, and that serious efforts are indeed currently undertaken to achieve this. That is especially the case in terms of establishing new institutions and organisations for spin-off purposes. However, the Soviet industrial inheritance and the general deficiencies of the Russian politico-economic system, such as lack of competition, seem set to undermine many of the potential positive effects of these efforts.

Notes

1. OPK is an abbreviation for *oboronno–promyshlennyi kompleks* (defence–industrial complex), serving as a shorthand for the Russian defence industry.

2. The Russian government has about 40 such programmes, of varying sizes, for the promotion of different sectors of the economy and society. See also Nikolskii (2015).
3. http://government.ru/media/files/cAqtUAQNkWY.pdf
4. Former Saint Petersburg State University of Information Technologies, Mechanics and Optics.
5. In Russian: *Grazhdanskie tekhnologii oboronno-promyshlennogo kompleksa.*
6. In Russian: *Goskorporatsiia Rostekh*.
7. In Russian: *Razvitie otechestvennogo stankostroeniia i instrumentalnoi promyshlennosti na 2011 – 2016 gody* and *Natsionalnaia tekhnologicheskaia baza na 2007–2011 gody*.
8. In Russian: *Razvitie elektronnoi komponentnoi bazy i radioelektroniki na 2008–2015 gody* and *Razvitie elektronnoi i radioelektronnoi promyshlennosti na 2013–2025 gody*.

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