The Russian machine tool industry

Prospects for a turnaround?

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Summary

After decades of neglect and weak demand for its products, the Russian machine tool industry is in a deep crisis. The great demand for machine tools that nevertheless exists in the Russian industry, not least within the defence industry, is now mostly covered by import, and Russia has become the fourth largest importer of machine tools in the world.

This study explores the state within the Russian machine tool industry in light of the global development trends within this industry. The question is whether or not there are any prospects for a turn-around within the Russian machine tool industry. Given the machine tool industry's strategic importance – not least for production of advanced arms systems – the domestic industry's prospects will have repercussions on Russia's ability to meet its geostrategic and foreign policy goals.

Keywords: Russia, industrial organisation, machine tool industry

Sammanfattning

Efter årtionden av försummelser och svag efterfrågan på dess produkter, befinner sig den ryska verktygsmaskinindustrin i en djup kris. Den stora efterfrågan på moderna verktygsmaskiner som ändå föreligger inom den ryska industrin, inte minst inom försvarsindustrin, täcks idag till större delen av import, och Ryssland har kommit att bli världens fjärde största importör av verktygsmaskiner.

Den här studien studerar tillståndet inom den ryska verktygsmaskinindustrin i ljuset av de globala utvecklingstrenderna inom denna industribransch. Frågan är om det föreligger några förutsättningar för en återhämtning inom den ryska verktygsmaskinindustrin. Med tanke på dess strategiska betydelse – inte minst för produktion av avancerade militära system – kommer framtidsutsikterna för den inhemska verktygsmaskinindustrin att få konsekvenser för Rysslands förmåga att uppfylla sina geostrategiska och utrikespolitiska mål.

Nyckelord: Ryssland, industriell organisation, verktygsmaskinindustri

Foreword

This report on the Russian machine tool industry is produced within the framework of the Russia and Eurasia Studies Programme (Russian foreign, defence and security policy) at the Swedish Defence Research Agency (FOI), which provides analyses for the Swedish Ministry of Defence. The programme focuses on research in Russian security studies, including Russia's neighbourhood, military, economic and domestic affairs. Every third year the programme produces a ten-year assessment of Russian military capability. In this report, Tomas Malmlöf stresses the key position of the machine tool industry in the manufacturing system and its crucial role for production within other industries. This makes the machine tool industry a necessary precondition for any other parts of the defence industry, and is therefore also of substantial weight for Russian military capability.

We are indebted to Associate Professor Stephen Fortescue, University of New South Wales, Australia, for his thorough review of the draft. Thanks also to our colleagues at FOI – Carolina Vendil Pallin, Susanne Oxenstierna, Gudrun Persson, Fredrik Westerlund, Jonas Kjellén and Bengt-Göran Bergstrand – who all read and commented on the draft of this report. Thanks also to Richard Langlais, who language-edited the report.

Jakob Hedenskog

Head of the FOI Russia and Eurasia Studies Programme

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Contents

Acronyms

CECIMO	European Association of the Machine Tool Industries	*Comité européen de coopération des industries de la machine-outil*
CNC	Computer numerical control	
EDM	Electrical discharge machining	
EFTA	European Free Trade Association	
EU	European Union	
FTP	Federal Target Programme	*FTsP, Federalnaia tselevaia programma*
GDP	Gross domestic product	
HS	Harmonized Commodity Description and Coding System, usually referred to as the Harmonized System	
IoE	Internet for Everything	
IoT	Internet of things	
ITC	International Trade Centre	
JSC	Joint stock company	
MITI	Japanese Ministry of International Trade and Industry	
NACE Rev. 2	EU statistical classification of economic activities	*Nomenclature statistique des activités économiques dans la Communauté européenne*
NC	Numerical control	
OAO	Joint stock company	*Otkrytoe aktsionernoe obshchestvo*
OEE	Overall equipment effectiveness	
OEM	Original equipment manufacturer	

OKPD	Russian Classification of Production by Type of Economic Activities	*Obshcherossiiskii klassifikator produktsii po vidam ekonomicheskoi deiatelnosti*
OKVED	Russian Classification of Economic Activities	*Obshcherossiiskii klassifikator vidov ekonomicheskoi deiatelnosti*
RSFSR	Russian Soviet Federative Socialist Republic	
SCP	Structure, conduct, performance	
SMEs	Small- and medium-sized enterprises	
UIIS	Unified Interdepartmental Information-Statistical System	*EMISS, Edinaia mezhvedomstvennaia informatsionno-statisticheskaia sistema*
UNIDO	United Nations Development Organisation	
UNSD	United Nations Statistics Division	
WCO	World Customs Organization	
WTO	World Trade Organization	

1 Introduction

While contributing to only a small fraction of total industrial production, the machine tool industry provides the principal industrial equipment base for all other manufacturing industries. It is closely associated with its main markets – heavy industry, the machinery industry, the car industry, power engineering, shipbuilding, the aircraft industry and the entire defence industry. In view of this central role in the industrial economy, it is considered as strategically important in all countries where it is present.

In Russia, where the domestic defence industry is by far the largest consumer of machine tools, it is even considered a matter of national security, especially as regards access to high-technological and dual-use machine tools. Demand for new and modern machine tools within the defence industry has increased significantly under the implementation of the State Armament Programme 2011–2020. Despite this boost in demand, Russia has so far failed to build on – or even preserve – the machine tool industry that it inherited from the Soviet Union, as users have preferred to invest in foreign-made machine tools. The aim of this study is to explore the underlying causes for this failure and analyse the prospects for an industrial turnaround.

Transition from Soviet to Russian machine tool industry

The Soviet machine tool industry was by and large a post-revolutionary product.[1] It underpinned Soviet industrialisation and armament for almost 70 years and helped to transform the Soviet Union into a superpower. Over time, the Soviet Union succeeded in building a rather strong rate of production of machine tools. In the early 1980s, it became the world's third-largest manufacturer of machine tools, with 15.8 per cent of total world production, surpassed only by Japan (18.1 per cent) and West Germany (16.4 per cent).[2] In 1990, the sector ostensibly employed 1.8 million workers at more than 9 000 research institutes, design bureaus and production enterprises and was responsible for more than a quarter of Soviet output.[3]

These impressive statistics notwithstanding, there were indications that the Soviet machine tool industry had lagged behind and lost in competiveness during the

[1] Although Soviet statistics on production were inherently flawed in many ways, there are good reasons to assume that they were flawed systematically. The numbers presented here thus give a good indication of the degree of the decline, which in itself is unquestionable.

[2] The UNIDO Secretariat (1991): The World Machine-Tool Industry – Background paper, United Nations Development Organisation, ID/WG.514/4, 28 June, *https://open.unido.org/api/documents/4990657/download/UNIDO-Publication-1991-4990657*, [accessed February 05, 2018], p. 52.

[3] *Ibid.*, p. 65.

1970s–1980s. Like most other established machine tool manufacturers at that time, the Soviet Union had failed to catch the initial transition led by Japan and followed by a handful of early adopters to numerically controlled machine tools and, later on, the computerisation of the numerical controls.[4]

Although the value of Soviet production continued to grow throughout the 1980s, it was outperformed by Japanese and West German manufacturers. In 1989, the ratio of Soviet export to total production of machine tools had shrunk to half its value ten years earlier. Concurrent with this development, the Soviet Union became the world's second-biggest importer of machine tools, next only to the United States, another late adopter of the on-going technological changes. In the Soviet case, imports amounted to one-fourth of total demand during the late 1970s. A decade later, this ratio had increased to about one-third.[5]

The machine tool industry that the Russian Federation came to inherit was therefore poorly equipped to deal with the economic shocks that followed upon the Soviet collapse. In 1990, production of metal-cutting machine tools in the soon ceasing to exist Russian Soviet Federative Socialist Republic, RSFSR, had amounted to 74 000 pieces. In the next five years, output fell to 18 000 pieces, according to official statistics. In 2009, it had shrunk to 2 000 pieces. Since then, the situation has somewhat stabilised, and in 2016 production of metal-cutting machine tools reached almost 4 400 pieces.[6]

However, as indicated above, the crisis in the Russian machine tool *industry* was not a crisis for the Russian machine tool *market*, as such. What happened was that the domestic machine-building industries increasingly turned to foreign machine tool providers. According to data from Gardner Research, a market research firm specialising in the manufacturing industry, Russian import of machine tools increased rapidly, and during the last decade it has equalled 80–90 per cent of demand per annum.[7] Russia had by then in practice given up any ambition it might have had to preserve a domestic machine tool industry that was able to remain the principal supplier for the domestic market.

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4 Arnold, Heinrich (2001): 'The recent history of the machine tool industry and the effects of technological change', *LMU Working Paper 2001–14*, Institute for Innovation Research and Technology Management, University of Munich, *www.scribd.com/document/126149427/The-recent-history-of-the-machine-tool*, [accessed February 02, 2018], p. 1.

5 The UNIDO Secretariat, *op. cit.* tables on pp. 52, 90–91, and author's own calculations. Demand is here defined as: production + import – export.

6 Egorenko, S., N. (ed.), (different years): *Regiony* Rossii. *Sotsialno-ekonomicheskie pokazateli*, Federalnaia sluzhba gosudarstvennoi statistiki, table 'Proizvodstvo metallorezhushchikh stankov', *www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/publications/catalog/doc_1138623506156*, [accessed February 08, 2018]

7 Gardner Research: 'The 2012 World Machine-Tool Output & Consumption Survey'; 'The World Machine Tool Output & Consumption Survey 2013'; 'The World Machine-Tool Output & Consumption Survey 2014'; 'World Machine-Tool Output & Consumption Survey 2015'; 'The World Machine Tool Survey 2016', all available at *www.gardnerweb.com/articles/list/223*

Implications of a dysfunctional machine tool industry

The greatest worry of Russia's decision-makers regarding the present situation is the strategic risks that are entailed in a dysfunctional domestic machine tool industry, combined with overwhelming dependence on foreign suppliers. According to the economic development path for Russia that its leadership publicly envisages, modern machine tools are not only a key driver for the technological revival of the Russian defence industry, which is an imperative for the realisation of its ambitious armament plans since the 2010s; they are also a necessary prerequisite for its entire machine-building industry, and thus for the envisaged transition from an economy dependent on gas and oil to a technologically-advanced manufacturing economy.

The dominance of foreign suppliers on the Russian machine tool market for the last two decades is therefore perceived as a genuine threat to these plans. So far, even Russia's defence companies prefer to buy foreign-made machine tools over domestic ones for the re-equipping of their manufacturing plants. The current sanctions regarding dual-use products that the United States, Europe, Japan and some other countries imposed on Russia in 2014 that affect machine tools have sharpened the urgency to get the domestic machine tool industry back on track.

Are there any prospects, then, for such a turnaround? Or is it too late to prevent the industry's further deterioration and Russia's continued dependence, even within the defence sector, on foreign machine tool makers?

1.1 Purpose and method

This study explores the current state of the Russian machine tool industry in light of current trends and developments within the global machine tool sector. In particular, it focuses on the Russian machine tool industry's current structure and the government's efforts to reshape the home market for machine tools to put the domestic industry back on track.

More specifically, the study examines whether or not there are any prospects for the Russian machine tool industry to increase its share of the home market and once again become the major supplier of advanced machine tools to Russia's strategic industries. Depending on whether or not Russia will succeed in its endeavours, it will have repercussions on its ability to meet its geostrategic and foreign policy goals.

Analytical framework

The setup and approach of this report draw foremost on ideas that stem from industrial organisation theory as well as game theory and public choice theory. Lest not to burden the text with an abundance of scholarly discussions that might otherwise divert the reader from the main topic, references and comments on this rich

corpus of academic literature have been kept to a minimum. The main inspiration for the analytical framework below is the industry structure–conduct–performance model, SCP, developed by Joe S. Bain in 1959, which predicts a simple causal relationship running from structure through conduct to performance with performance dependent on industry structure.[8]

To determine the competitive position of the Russian machine tool industry given its specific industry structure, this study uses Michael Porter's five forces framework. According to Porter, 'industry structure is embodied in five competitive forces that collectively determine industry profitability: the power of suppliers, the power of buyers, the threat of new entrants, the threat of substitute products, and the rivalry among existing competitors'. It is their collective and individual strengths, as well as their alterations over time, that determines the average profitability and either improves or erodes the attractiveness of an industry.[9]

In addition, the study uses elements of game theory as well as public choice theory, in the latter case not least to take into account the formidable role of the government in Russia's economy.[10]

Definitions

In this study, an industry is defined as a set of firms or companies pursuing an identical or reasonably similar business activity or commercial enterprise that can be isolated from other business activities or commercial enterprises. To distinguish one industry from another, government statistical agencies are usually helpful, as they report descriptive information about economic activities in accordance with standardized classification systems and methodology. It is the principal activity of a firm that determines which industry it belongs to. The principal activity of a statistical unit is defined as the activity that contributes most to the total value added of that unit. The principal activity does not necessarily account for 50 per cent of the unit's total value added.[11]

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8 Bain, Joe S. 1959, 2nd ed., 1968. Industrial Organization: A Treatise, John Wiley, New York; Hartley, Keith (2014): The Aerospace Economy of Aerospace Industries – A Key Driver of Growth and International Competiveness? Edward Elgar Publishing Ltd., p. 77.

9 Porter, Michael E. (2008): *On Competition*, Harvard Business Press, p. 84.

10 On public choice theory, see, for instance, Buchanan, J. 1986, *Liberty, Market and the State*, Harvester, London; Tisdell, C. and Hartley, K. 2008, *Microeconomic Policy*, Edward Elgar Publishing, Cheltenham, U.K. and Northampton, MA, USA.

11 Eurostat (2008): NACE Rev. 2: Statistical classification of economic activities in the European Community, *http://ec.europa.eu/eurostat/en/web/products-manuals-and-guidelines/-/KS-RA-07-015*, [accessed March 27, 2018]

According to the identical definitions that the European Union and the Russian Federation use in their statistical publications (NACE Rev. 2 and OKVED 2),[12] the principal activity of the machine tool industry is the 'manufacture of metal forming machinery and machine tools'. Both systems identify this activity with the same four-digit numerical code, 28.41. This is no coincidence, but a reflection of the EU-Russia cooperation on statistics and statistical nomenclature.

What exactly then is metal-forming machinery, or a machine tool? According to Gardner Research, 'a machine tool [or metal-forming machinery] is usually defined as a power-driven machine, not portable by hand, and powered by an external source of energy. It is specifically designed for metalworking either by cutting, forming, physic-chemical processing or a combination of these techniques'.[13]

In contrast to other machines, which are generally dedicated to the production of a particular product, machine tools are usually categorised on the basis of their ability to execute a specific process.[14] The basic distinction is between metal-cutting or chip-making machine tools and metal-forming machine tools. About three-quarters of all machine tools produced are for metal-cutting purposes and one-quarter for forming. This figure has been fairly constant over time, even if the structure of the subgroups has changed.[15]

In the European and Russian statistical nomenclature for products according to activity (CPA 2008 and OKPD-2)[16], metal-forming machinery and machine tools are classified according to a six-digit numerical code. The first four digits are identical to the previously described distinguishing code for the machine tool industry. The last two digits specify the most important making or cutting and metal-forming processes used for working metal, as shown in Table A:1, in the Appendix.

Another widely used statistical nomenclature is the Harmonized Commodity Description and Coding System, usually referred to as the Harmonized System, or HS. This system was developed by the World Customs Organization (WCO) and forms the basis for customs tariffs and trade statistics. Metal-cutting machines are related to the codes 8456 through 8461, with metal-forming machines as 8462 through 8463, as demonstrated in Table A:2 in the Appendix. The numerical codes are thus different, but, at four-digit level, the HS classes more or less correspond

[12] Statistical classification of economic activities in the European Community (NACE Rev.2)*; Obshcherossiiskii klassifikator vidov ekonomicheskoi deiatelnosti (OKVED 2)* [Russian Classification of Economic Activities].

[13] Gardner Research: 'World Machine-Tool Output & Consumption Survey 2015', p. 3, *www.gardnerweb.com/articles/list/223*

[14] The UNIDO Secretariat, *op. cit.* p. 13.

[15] The UNIDO Secretariat, *op. cit.* p. 19.

[16] Classification of Products by Activity (CPA 2008); *Obshcherossiiskii klassifikator produktsii po vidam ekonomicheskoi deiatelnosti (OKPD 2)* [Russian Classification of Production by Type of Economic Activities].

to the six-digit classes used in the EU and Russian statistical systems mentioned above.

A third way to separate one machine tool from another is by their means of control. A usual distinction is between conventional, automatic and numerical control machine tools. Conventional machine tools are operated by a machinist, who manually directs the machine. Automatic machine tools are built to carry out a specific sequence of operations in a mechanized process. Their lack of flexibility means that their main field of application is mass production of large series of identical details. A numerical control machine tool (NC) is controlled by a numerical form of input. Earlier, numerical controls used punch cards or magnet tapes. Later on, they were replaced by computer numerically-controlled (CNC) machine tools, where a computer replaces the fixed logical element that is at the core of an NC system. Cutting machines are more affected by the digital revolution in machine tool design than metal-forming tools.

Scope

The focus of this study is the structure of the Russian machine tool market and its domestic machine tool industry as well as government industry policies. The study also draws on some data from the global machine tool market and industry in order to obtain suitable benchmark data when relevant.

In order to perform a more complete analysis of the prospects of the Russian machine tool industry, it would have been necessary for the study to include an assessment of company conduct and performance in accordance with the SCP model described above. Which strategies do the Russian machine tool companies use to mitigate their situation and improve their competiveness, and does the outcome of these strategies indicate an improved performance in terms of increased output and better financial results over time? However interesting and relevant these questions may be, they have had to be excluded from this report since time was not permitting. However, it would be interesting to return to these questions in a separate study.

Some readers might note the lack of a discussion about the role and levels of corruption within the Russian machine tool industry and their impact on industry performance, as corruption is a well-known and recurrent problem in the Russian economy in general. Of interest to an industry study is especially the interface between the company and the state, or, more specifically, the interaction between company conduct and state support and subsidies. To what extent are resources put to proper use, and how much is wasted? This topic is nevertheless beyond the scope and purpose of this report and has therefore also been excluded.

Due to these limitations, the approach of the study is macro-sectoral rather than micro-sectoral. Some of the analytical consequences are a possible overemphasis on certain macro-sectoral factors as determinants of the condition of the Russian

machine tool industry, as well as an overly schematic and shallow understanding of firm conduct and industry performance. In spite of these weaknesses, an analysis of the Russian machine tool industry's structure, current state policies and state support still provides a good indication of whether the industry has any prospects of revival or if it will continue to muddle through.

The time frame for the study is the period 1991–2030, with emphasis on the 2010s. There are two good arguments for using 2030 as an end-year for the study. The first argument relates to the classified Russian State Armament Programmes (GPVs, in Russian).[17] These programmes are Russia's main planning tool for arms procurement. As such, they are implicitly the main source for the domestic defence industry's demand for advanced machine tools. The latest armament programmes have also been linked with targeted industrial support programmes that serve as capital investment enablers for the defence industry. In this way, it is highly likely that the implementation of the 2018–2027 State Armament Programme will have a significant, or even decisive, impact on the development of an important segment of the Russian machine tool market for at least the next coming decade.

The second argument relates to the Russian Government's direct support to the machine tool industry. In June 2017, the Ministry of Industry and Trade under Minister Denis Manturov proposed a new development strategy for the machine tool industry for the period 2018–2030.[18] Even if the strategy is as of yet (December 2018) only a proposal waiting for adoption or further processing, it is unlikely that the final version will deviate significantly in substance or form from the present outline. This report therefore assumes that it is possible to make forecasts or guesstimates about the standing of the Russian machine tool market and its domestic machine tool industry up to 2030 based on the Ministry of Industry and Trade's proposal for a new development strategy from June 2017.

Sources

For aggregated global data, the annual World Machine Tool Survey from Gardner Research has been a valuable source. It compiles country data on production, consumption, exports and imports of machine tools. The countries represented do not include all machine tool production and trade activity in the world, but likely encompass more than 95 per cent of all activity.[19] Another source for global data has been the ITC Trade Map database, which is based on customs statistics.

[17] In Russian: Gosudarstvennaia programma vooruzheniia.

[18] Minpromtorg (2017): Strategiia razvitiia stankoinstrumentalnoi promyshlennosti do 2030 goda, 6 June, *http://minpromtorg.gov.ru/common/upload/docs/strategy/project.pdf*, [accessed March 5, 2018]

[19] Gardner Research: 'The World Machine-Tool Output & Consumption Survey 2014, p. 17, *www.gardnerweb.com/articles/list/223*

As for Russian data, quantitative and qualitative information from relevant official policy programmes has been central to the study. The study also draws on analyses, interviews and similar material found in Russian mass media.

1.2 Outline

The study is organised as follows. *Chapter 2* describes the global machine tool industry and serves as a benchmark for the remaining chapters. It discusses the industry's strategic significance, main characteristics, origins and possible development for the next decades. The final section in this chapter gives an overview of the global market trends regarding producers, consumers and trade patterns. Those who are familiar with this general background might prefer to forego this chapter and start their reading with Chapter 3.

Chapter 3 focuses on the main features of the Russian market for machine tools. It analyses how the market has developed since the early 1990s, market demand formation and structure, as well as the largest foreign providers of machine tools at country level.

Chapter 4 analyses the structure of the Russian machine tool industry. It builds on the assumption that it is the number of firms and their size together with specific market forces that shape competition and sets the limits for industrial profitability. These are the prerequisites for corporate performance and the boundaries business strategies need to adhere to, and in Russia they do not work in favour of Russia's machine tool manufacturers.

Chapter 5 describes how government support to the domestic machine tool industry materialised. It also analyses the form and content of implemented policies as well as further planned support measures until 2030. In addition it evaluates the effectiveness of these policies.

Chapter 6 sums up the findings from the previous chapters. In particular it discusses their repercussions for the further development of the Russian machine tool industry. In line with the research question, a central issue is the industry's prospects for taking back the domestic machine tool market and once again becoming the main provider of advanced machine tools to Russia's strategic industries.

2 The global machine tool industry

2.1 Machine tool manufacturing – a strategic industry

The machine tool industry is usually a small one, even in countries with a comparatively large output of machine tools. For instance, in 2017 the production value of Japan's machine tool industry – the second largest in the world – accounted for only 1.9 per cent of the value of its entire machinery production.[20] All the same, this industry occupies a very special position in the economy, bearing the hallmarks of an industry of strategic importance.

First, it is *economically strategic*. As such, it fulfils the basic function of production of the means of production. It supplies the machines for cutting, forming and shaping the metals upon which a large share of the manufacturing industries depend. Together with the power generation industry, it is the carrier of the industrial revolution and mass production, a necessary prerequisite for the material base of any developed society. Without the manufacturing technologies related to machine tools – the quintessential investment good – other manufacturing industries would barely exist.[21]

Second, the machine tool industry is *technologically strategic*. The state of the art of the machine tools, their control systems and the organisation surrounding them largely determines the productivity and competiveness of engineering industries in general.[22] The industry is furthermore a likely source for technological spin-offs and for technology transfer between companies and from one industrial sector to another. The machine tool industry is therefore vital to a country's technological security and the technological level of its economy.[23]

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[20] Japan Machine Tool Builders' Association (2018): 'Size of the Japanese Machine Tool Industry', 10 August, *http://www.jmtba.or.jp/english/category/machine-tool-statistics/*, [accessed September 09, 2018].

[21] Alexander, Arthur J., (1990): Adaption to Change in the U.S. Machine Tool Industry and the Effects of Government Policy, The RAND Corporation, Santa Monica CA, N-3079-USJF/RC, *www.rand.org/pubs/notes/N3079.html*, [accessed February 02, 2018], p. 1.

[22] Carlsson, Bo (1983): 'The Machine Tool Industry – Problems and Prospects in an International Perspective', *Working Papers, no 97*, Industrial Institute for Economic and Social Research (IUI) [since 2006 Research Institute of Industrial Economics; Institutet för näringslivsforskning], *www.ifn.se/eng/publications/wp/1976-1990_1/1983/96*, [accessed February 01, 2018], p. i.

[23] Gribkov, A., Zakharchenko, D., & Kornienko, A. (2014): 'Competitiveness of the Russian Machine Tool Industry, *Problems of Economic Transition*, vol. 57, no. 4, *http://www.tandfonline.com/doi/abs/10.2753/PET1061-1991570403*, [accessed February 01, 2018], pp. 53–69.

Third, as an essential key to a strong defence industrial base, this is also an industry of *military-strategic* importance. Production of weapons and arms platforms depends on a wide variety of manufacturing processes that often demand access to the latest process technology for cutting and shaping materials into required components. Of special interest to military applications are machine tools with five[24] or more axes that can be coordinated simultaneously for contouring control. Such turning, milling and grinding machines are required for the fabrication of everything, for instance, from large aircraft structures, submarine and ship propellers (particularly for silent propellers), and turbine and compressor blades to small parts for gyroscopes, engine parts, and even nuclear weapons. Grinding machines, in turn, are used to produce parts for stealth applications, smart weapons, sensors, night vision devices, laser mirrors, moulds for radar and sonar domes, and missile applications such as forward-looking infrared capabilities, gyroscopes, inertial navigation, and high-performance engine parts.[25] A major concern with five-axis machine tools is the possibility that they will be diverted or altered in order to machine items for unauthorized military uses. Many companies worldwide have therefore developed and installed automatic movement detection devices that will render their machine tools inoperable if they are physically moved from the locations they are installed in. The connectivity of CNCs to the Internet also allows sellers to verify that their machine tools are used for their intended purpose and not for producing something else.[26]

Yet another aspect of the military-strategic importance of machine tools is that military procurement requires expandable production capacity to manufacture end products and spare parts not only under peacetime conditions but also during mobilisation and extended military conflicts.[27] The location of machine tool production facilities might therefore be a matter of national security. In a serious national emergency, there are no guarantees that trade relations with foreign machine tool

[24] Although 6-axis CNC machines do exist, 5-axis configurations are more common, since adding a sixth axis typically offers few additional benefits. The Cartesian three-dimensional space, represented by the variables x, y and z, covers the first three axes in 5- and 6-axis machining. The remaining two or three axes are represented by the variables A, B and C, which describe the rotational axes around x, y and z respectively. In flight dynamics, A, B and C are referred to as roll, pitch and yaw.

[25] U.S. Department of Commerce (2009): 'Critical Technology Assessment: Five Axis Simultaneous Control Machine Tools' Office of Technology Evaluation Bureau of Industry and Security, *www.bis.doc.gov/index.php/forms-documents/doc_view/138-five-axis-simultaneous-control-machine-tools*, [accessed September 09, 2018], p. 5.

[26] U.S. Department of Commerce, *op. cit.*, pp.12–13

[27] National Research Council (1983): U.S. Machine Tool Industry and the Defense Industrial Base, The National Academies Press, Washington, DC, *www.nap.edu/read/19524/chapter/2*, [accessed February 01, 2018], p. 1; Joint Economic Committee (1983): The Machine Tool Industry and the Defence Industrial Base – Hearing before the Joint Economic Committee Congress of the United States, First Session, June 7, U.S. Government Printing Office, *http://njlaw.rutgers.edu/collections/gdoc/hearings/8/84601695/84601695_1.pdf*, [accessed February 01, 2018], p. 1.

suppliers can be upheld without disruptions and disturbances due to boycott regimes or open acts of war.

2.2 Industry characteristics

In contrast to other segments of the capital goods industry, economies of scale are less important in machine tool manufacturing. This tendency is especially strong in the area of high-end, special purpose or custom-made machine tools vis-à-vis general purpose machine tools. Even large producing countries are usually dominated by small or medium enterprises.[28] For instance, the European Association of the Machine Tool Industries, CECIMO,[29] states that over 80 per cent of the 1 300 industrial enterprises it represents through fifteen national associations (EU, EFTA, Turkey) are small- and medium-sized enterprises, SMEs.[30] One possible reason for the lack of scale economies is that the share of capital in total production costs is generally low.

Still, large companies do exist and mergers and acquisitions also take place, which indicates that economies of scale are obtainable within the machine tool industry, at least under certain conditions. For instance, a proven strategy that was introduced by Japanese companies during the 1980s was to emphasize modularity and specialization of component production in machine tool design. In this way, they were able to combine the advantages of scale economies and tailor-made products.[31] Scale economies also become important with increased exports because of the expense of world-wide marketing and the need for after-sales networks.[32]

Machine tool manufacturing is based on mature mechanical engineering technologies and digital control technology. It often borrows technology from its customers and diffuses its technological knowledge to other customers, sometimes in different industries. As a rule, its manpower has a higher level of qualification than the average level for manufacturing industries.

An important feature of the machine tool industry is its highly volatile cyclicity. This is because machine tools are not just another primary input in the production process, but are used to produce other investment goods. It therefore suffers a double effect of the accelerator principle: when demand in final products decreases, demand for investment goods falls even more, and demand for machine tools falls

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28 Alexander, *op. cit.*, pp. 9-10.

29 French abbreviation for Comité européen de coopération des industries de la machine-outil.

30 CECIMO (2017?): About CECIMO [online], *www.cecimo.eu/site/home/*, [accessed April 12, 2018]

31 Alexander, *op. cit.*, p. 18.

32 Frischtak, Claudio R. et al (1986): India – Industrial Regulatory Policy Study (Vol. 2): Subsector reports, World Bank Group, Washington DC, *http://documents.worldbank.org/curated/en/379671468259743153/Subsector-reports*, [accessed December 06, 2018], p. 86.

the most. Along these lines, the swings in machine tool orders are magnified versions of the rises and falls of general economic demand of industrial investment.[33]

A side-effect of the large fluctuations in output is that the industry's own demand for labour shows a similar pattern. In the worst case, this characteristic might deter capable persons from joining the industry, due to the high probability of periodic layoffs.[34] In general, production in machine tool companies with a large export share is not as volatile as in companies that are more dependent on the ups and downs of domestic demand.[35]

2.3 Development of the machine tool industry

From mechanics to mechatronics

The modern machine tool industry emerged in the early days of the industrial revolution as an increase in mechanization required more metal parts in machinery. A handful of major industries spurred machine tool development in firearms and artillery, the clock industry, textile machinery, steam engines, sewing machines, bicycles, automobiles and aircraft. Most of the methods for working metals that are still used in metal-forming machinery and machine tools were developed over the course of the 19th century. The early 20th century imposed demands for higher precision in manufacturing tolerances and also involved some material development. In the early 1940s, two Soviet scientists discovered a new working method, electrical discharge machining, EDM, which is a processing method used primarily for hard metals that would be difficult to machine with traditional techniques.

Innovation in the machine tool industry was incremental until the occurrence of numerical controls upset the industry and caused considerable problems for established companies, since they had underestimated the impact of the new technology. The integration of digital control technology and computers into machine tools hit the industry in three waves of technology shocks that lasted about ten years each. The introduction of numerical controls (NC) for machine tools in the 1950s and 1960s enabled some degree of automation of production processes. The second wave, in the 1970s and 1980s, entailed the use of microcomputers for numerical control (CNC). CNC machines offered new features, were more flexible and led to a substantial drop in price. The present, third wave is comprised of the PC-based CNC machine and began around 1990. It has enabled an increase in graphical user interfaces as well as data transmission through local area networks, LANs.[36]

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[33] Alexander, *op. cit.*, p. 1.
[34] The UNIDO Secretariat, *op. cit.* pp. 28–30.
[35] Carlsson, *op. cit.*, p. 13.
[36] Arnold, *op. cit.*, pp.1, 21–28.

The introduction of digital controls had a disruptive market impact. First, numerical control enabled fundamental changes in product architecture as several processes converged into multi-purpose machines.[37] Flexibility in design, development and production increased, which resulted in shorter product cycles, faster product development and a push for speedier order delivery.[38] Second, as the industry's emphasis altered from mechanics to electronics, it moved away from its traditional role as a subsector to the non-electrical machinery industry and developed into a subsector of mechatronics – the combination of mechanical engineering and electronics.[39] The core competence of manufacturing therefore shifted from accurate mechanics to electrical engineering and programming. This disruption in competence also caused the vertical disintegration of production and competition for components and parts on a global level.[40] The global machine tool industry has therefore gradually moved towards more layered production, with tiered supply chains and, at the top, original equipment manufacturers (OEMs).[41]

In the 2010s, various additive manufacturing came into maturity and began to make serious inroads in metalworking. It then became clear that removal of metal with the use of different kinds of machine tools was no longer the only metalworking process for transforming metal into a desired shape. Additive manufacturing is thus complementary or subsidiary to the subtractive technologies used in traditional machine tools. It is obvious that it is having an impact on the machine tool market and that a possible new market rupture or paradigm shift is yet to come.

Development of new business models

Regarding the present business development that materialized in earnest in the 2010s, an underlying driver for the entire manufacturing industry is a universal convergence of industrial production with information and communication technologies. Sometimes, this convergence is identified either as 'Industry 4.0', thus alluding to a fourth industrial revolution,[42] or as the emergence of an Internet for

[37] *Ibid.*, p. 22.
[38] Alexander, *op. cit.*, p. vi.
[39] The UNIDO Secretariat, *op. cit.* p. 30.
[40] Alexander, *op. cit.*, p. vi.
[41] Gümüşdere, Gökalp (ed.) (2013): 'Supply chain relations', Drivers of Growth in the European machine tool industry, CECIMO, *www.cecimo.eu/site/fileadmin/Publications/Studies_and_Reports/Drivers_of_growth_in_the_MT_industry.pdf*, [accessed April 3, 2018], p. 4.
[42] The first three industrial revolutions were about the introduction of mechanical production facilities from the second half of the 18th century and onwards; electrification from the 1870s and division of labour (Taylorism); and the digital revolution from the 1970s, which enabled further the automation of production processes.

Everything (IoE) that connects people and things, such as machines and products, with data.[43]

CECIMO describes the impact of this convergence on the machine tool industry in terms of an on-going paradigm shift where some companies have started to transform from being pure machine suppliers to 'process solution partners' that are more or less integrated into their customers' business and manufacturing processes.[44]

Three trends underpin this development. The first builds on systematic analysis of customer data regarding production, processes, value chain, available machinery, order data and so forth, in order to optimize the customer's overall equipment effectiveness (OEE). This approach offers much higher customer benefit than any performance improvement of individual machines might bring about. The second trend is the machine tool industry's movement towards a new business model characterised by life-cycle service and leasing contracts instead of hardware sales; the customer thus rents the entire machine park from a machine tool company instead of buying each machine piecewise. This trend also builds on analysis of live customer data and aims to improve the industry's predictive maintenance models and to offer higher service quality to the customers. None of these two trends would have been possible, however, if they had not been supported by a third trend, namely further development of the machine human interface, including application-focused software, big data analytics, platforms for Internet of Things (IoT) and cloud service solutions.[45] However, since mid-sized machinery companies have neither the financial nor other resources to develop proprietary solutions on their own, their way forward probably lies in partnerships with suitable software and digital service providers. The main issue for the machine tool companies in these partnerships will be to continue to control the interface with their customers in order to avoid degenerating into subcontractors to the software industry.

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[43] Hermann, Mario, Pentek, Tobias & Otto, Boris (2016): 'Design Principles for Industrie 4.0 Scenarios', Conference paper: *49th Hawaii International Conference on System Sciences (HICSS)*, DOI 10.1109/HICSS.2016.488, *http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7427673*, p. 3929, [accessed March 26, 2018]

[44] Bellersheim, Volker (2017): 'Digital services in the machine tool industry', CECIMO magazine no 11, pp 17–18, *http://www.cecimo.eu/site/fileadmin/Magazine/CECIMO_Magazine_Spring_2017_LQ.pdf*, [accessed March 27, 2018]

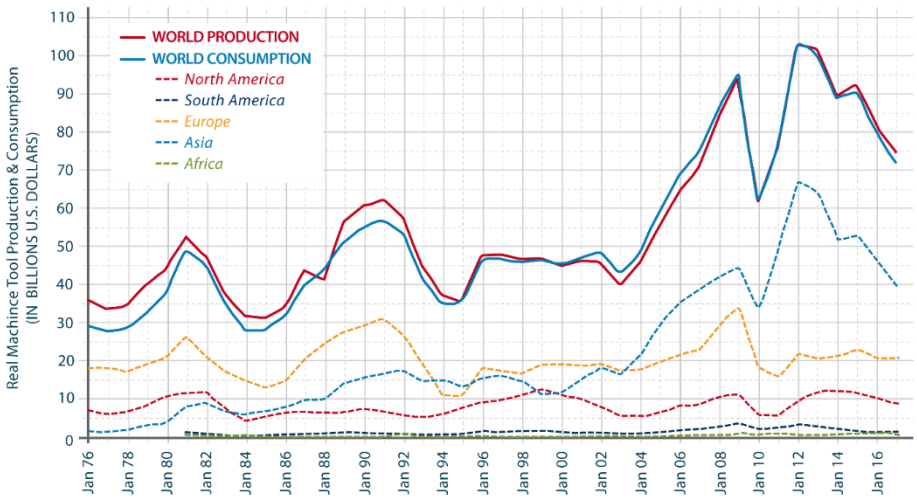
[45] Bellersheim, *op. cit.*, pp 17–18, *http://www.cecimo.eu/site/fileadmin/Magazine/CECIMO_Magazine_Spring_2017_LQ.pdf*, [accessed March 27, 2018]

2.4 The global market

World machine tool consumption 2003–2016

World machine tool consumption typically follows a cycle that lasts ten years between peaks. During the last decades, however, the peaks have become less regular.[46] The last boom began in 2003 and ended in 2011, despite a drastic decline in 2009, which was due to the U.S. subprime mortgage market crisis and developed into the global financial crisis of 2007–2008, as illustrated in Figure 1.

Figure 1: World machine tool production & consumption 1976–2016, by value[47]



The surge in demand 2003–2008 was driven by Europe and Asia in comparatively equal proportions, but the second boom, in 2010 and 2011, was almost exclusively caused by Asian demand. Low-cost and abundant labour combined with access to cheap investment capital pushed even more advanced manufacturing towards Asia, which in turn increased Asian demand for machine tools.[48]

As the demographic and financial factors then levelled out and manufacturing companies had to compete more in capabilities, the level of machine tool technology being purchased increased, although the overall level of consumption was

[46] Kline, Steven Jr. (2017): 'Understanding the Machine Tool Industry's Ups and Downs', *Modern Machine Shop*, Gardner Business Media Inc., May 2017, pp. 80–85, *https://mms.epubxp.com/i/813675-may-2017*, [accessed April 12, 2018]

[47] Gardner Research, '*The World Machine Tool Survey 2016*', p.3 World machine tool production & consumption [line graph], World machine tool consumption [line graph].

[48] Kline, Steven Jr. (2016): 'What's Happened Since the Peak', *Modern Machine Shop*, Gardner Business Media Inc., May 2016, *https://mms.epubxp.com/i/668899-may-2016*, [accessed April 12, 2018], pp. 100–104.

down. For instance, the computerisation of numerical controls allowed more complex production of machining centres that combine several different machine tools. Another important achievement that depends on contemporary advancements in computer hardware and software is five-axis machining, *i.e.* involving a machine that is able to move a tool or a part on five axes at once. Based on anecdotal evidence, Gardner Research maintains that four- and five-axis machines as well as multitasking machines are seeing strong demand around the world, while commodity-type – *i.e.* highly standardised – machines with little scope for product differentiation, are losing out.[49]

Producing countries

In the course of the last century, the machine tool industry underwent a significant shift when it comes to which individual producing countries dominated the market. By the turn of the twentieth century, the industry was dominated by British, German and U.S. firms. The two world wars strengthened the U.S. position until it became the biggest producer of machine tools, only to lose this position to West Germany and Japan due to the revolution in numerical control and the following technical development described above. China's appetite for machine tools increased significantly at the turn of the millennium, and by the 2010s it had become by far the largest producer, consumer and importer of machine tools.

Table 1 shows production data for all the world's top ten machine tool industries for 2014 and 2015. Based on the sample used by Gardner Research, these countries together account for almost 90 per cent of world machine tool production.[50] Neither Russia nor Sweden belongs to this group, but they have been included for comparison.

At first glance, China's leadership in machine-tool-building appears uncontested. However, the Chinese figures are not entirely comparable with data from other countries. In a previous survey, Gardner Research even reduced reported Chinese consumption and production by 65 per cent to account for the high percentage of non-CNC machines that are almost universally produced and consumed in China.[51]

[49] Kline, 'What's Happened Since the Peak', pp. 100–104.

[50] The sample consists of 60 countries and is based on all countries that imported machine tools for at least $100 million, in at least one year since 2001.

[51] Gardner Research: 'The World Machine-Tool Output & Consumption Survey 2014', p. 4, *www.gardnerweb.com/articles/list/223https://intranet.foi.se/sidor/forskning/projekt/projekthandboken.html*

Table 1: Global machine tool production, millions of U.S. dollars, constant value[52]

	Country	Production value 2014	Production value 2015	Percentage change	Share of world production, per cent	Accumulated share of world production, per cent
1	China	24 649.10	22 100.00	-10.3	27.6	27.6
2	Japan	14 857.20	13 489.50	-9.2	16.8	44.4
3	Germany	14 456.70	12 422.00	-14.1	15.5	59.9
4	Italy	5 797.70	5 306.30	-8.5	6.6	66.5
5	South Korea	5 675.40	4 758.00	-16.2	5.9	72.4
6	United States	5 480.40	4 600.00	-16.1	5.7	78.2
7	Taiwan	4 864.20	4 030.00	-17.1	5.0	83.2
8	Switzerland	3 681.30	3 052.80	-17.1	3.8	87.0
9	Spain	1 177.90	1 003.30	-14.8	1.3	88.2
10	Austria	1 049.50	938.00	-10.6	1.2	89.4
17	Russia	450.60	485.00	7.6	0.6	95.1
25	Sweden	193.30	159.90	-17.3	0.2	98.0

Japan's and Germany's positions in the table as number two and three, respectively, in machine-tool-building are uncontested by others, although their mutual rankings have shifted back and forth over time. Together with China, the top three countries' share of world production corresponds to 60 per cent of the grand total.

Russia, meanwhile, is the world's 17th-largest producer of machine tools. Nevertheless, its production only amounts to 0.6 per cent of world production.

Consuming countries

Table 2 presents the world's top ten machine tool consumers for 2014 and 2015. Their combined share corresponds to slightly less than 80 per cent of the world's consumption of machine tools, according to Gardner Research. China's consumption dominates the list; its share of world consumption amounts to more than one-third of the total and surpasses U.S. consumption – number two on the list – by 3.7

[52] Gardner Research, 'The World Machine Tool Survey 2016', *www.gardnerweb.com/articles/list/223*; author's own calculations.

times. The six largest consuming countries are the same as the six largest producing countries, although in a different order. Taiwan also appears on both lists. The remaining countries on the list of top ten consumers are Mexico, Russia and India. Russia's consumption totals 2.8 per cent of world consumption.

Table 2: Global machine tool consumption, millions of U.S. dollars, constant value[53]

	Country	Consumption value 2014	Consumption value 2015	Percentage change	Share of world consumption, per cent	Accumulated share of world consumption, per cent
1	China	31 800.0	27 500.0	-13.5	34.8	34.8
2	United States	8 811.1	7 361.0	-16.5	9.3	44.1
3	Germany	7 347.8	6 360.8	-13.4	8.1	52.2
4	Japan	5 307.1	5 804.5	9.4	7.4	59.5
5	South Korea	4 927.8	3 823.0	-22.4	4.8	64.4
6	Italy	2 866.6	3 136.1	9.4	4.0	68.4
7	Mexico	2 047.3	2 214.1	8.1	2.8	71.2
8	Russia	2 304.3	2 177.0	-5.5	2.8	73.9
9	Taiwan	1 815.3	1 564.0	-13.8	2.0	75.9
10	India	1 514.1	1 541.0	1.8	2.0	77.9
39	Sweden	202.6	167.6	-17.3	0.2	97.9

Global trade

Table 3 lists trade data from the Gardner Research sample for 2015. All data are sorted in falling order according to the trade balance column, and give some indication of the current competitiveness order within the global machine tool industry. This table also includes data for export as a share of production and import as a share of consumption. The export-to-production ratio illustrates commitment to export as well as relative competitive advantage for different industries. The import-to-consumption ratio is another measure of the relative competiveness of different industries, but the causality might be more complex. Dependence on foreign suppliers might indicate, for instance, that the domestic industry is less versatile and more specialised in the production of a certain kind of machine tools, or that current production capacity does not correspond to demand.

[53] Gardner Research, 'The World Machine Tool Survey 2016', *www.gardnerweb.com/articles/list/223*; author's own calculations.

In addition to the top ten producers, Sweden and Russia have been inserted for comparison, and the United States and China have been added, due to their weight in the two previous tables, for production and consumption, respectively.

Table 3: Global machine tool trade balance 2015, millions of U.S. dollars, constant value[54]

Country	Export	Import	Trade balance	Export/Production	Import/Consumption
1 Japan	8 625.5	940.5	7 685.0	0.64	0.16
2 Germany	8 792.0	2 730.8	6 061.2	0.71	0.43
3 Taiwan	3 186.0	720.0	2 466.0	0.79	0.46
4 Italy	3 641.1	1 470.9	2 170.2	0.69	0.47
5 Switzerland	2 586.5	571.7	2 014.8	0.85	0.55
6 South Korea	2 342.0	1 407.0	935.0	0.49	0.37
7 Spain	850.9	442.8	408.1	0.85	0.74
8 Austria	697.1	396.3	300.8	0.74	0.62
9 Czech Republic	693.8	610.6	83.2	1.08	1.09
10 Singapore	366.0	305.7	60.3	0.82	0.79
15 Sweden	238.7	246.4	-7.7	1.49	1.47
57 Russia	64.0	1 756.0	-1 692.0	0.13	0.81
59 United States	1 745.0	4 506.0	-2 761.0	0.38	0.61
60 China	3 200.0	8 600.0	-5 400.0	0.14	0.31

The five countries with the highest positive trade balance in the table are Japan, Germany, Taiwan, Italy and Switzerland. All five are highly dedicated to export. With Japan as the notable exception, the import-to-consumption ratio within this group varies between 43 and 55 per cent. Taken together, the top ten list is comprised of four Asian and six European countries. Their export-to-production and import-to-consumption ratios indicate their focus on export and high competiveness. The ratio data for the Czech Republic (and Sweden) stand out as they sum up to over 100 per cent, but are in both cases due to an extensive re-export of machine tools, *i.e.* trade.

The last countries in the table and in the Gardner Research sample are the United States and China. Although U.S. export is large in absolute numbers and its export-to-production ratio amounts to almost 40 per cent, the United States imports more than 60 per cent of its consumption of machine tools. Although Chinese export is

[54] Gardner Research, 'The World Machine Tool Survey 2016', *www.gardnerweb.com/articles/list/223*; author's own calculations.

comparatively impressive in absolute figures, they correspond to only 14 per cent of its production. At the same time, it imports a third of the machine tools it needs. China therefore runs a trade deficit in machine tools of 5 400 million U.S. dollars, the biggest in the world. Put together, this is a strong indication of Chinese non-competiveness.

According to Gardner Research, 'more than any other country in the world, China represents a distinctly two-sided, yet lop-sided, machine tool market'.[55] The low-end side of the market is much larger than the high-end side, and it even includes manual machine tools. The high-end side of the market gained momentum in the mid-2000s, when low interest rates enabled global manufacturing companies to exploit low labour costs by building new factories anywhere in the world. This side of the market is concentrated in the electronics and automotive sectors. It is also heavily dependent on the installation of more sophisticated machine tools by global manufacturers and high-end Chinese job shops.

Russia stands out from the other countries. Although its trade deficit is three-fifths of the U.S. deficit and just a third of the Chinese deficit, it has hardly any export at all. Its high import-to-consumption ratio demonstrates its actual dependence on import.

2.5 Summing up

The machine tool industry is an industry of major strategic significance, not least from a military perspective. It is also a highly volatile industry: its position within the economy means that its rises and falls are magnified versions of the general demand of industrial investment over an economic cycle.

The manufacture of machine tools is based on mature mechanical engineering technologies and digital control technology. Technological development has accelerated even more since the introduction of computerised control systems and data transfer over the Internet, paving the way for a fourth industrial revolution within the manufacturing industries. This fourth revolution is based on the third, which used electronics and information technology to automate production. What is new is its fusion of technologies, which is blurring the lines between the physical, digital and biological spheres.

The machine tool industry is especially affected by the introduction of a concept of an Internet of Things for the manufacturing industries, big data analysis and cloud service solutions. Their impact might well cause a general paradigm shift within the machine tool industry, as companies have to reconsider their strategies for competition and the long-term sustainability of their business models.

[55] Kline, 'Understanding the Machine Tool Industry's Ups and Downs', pp. 80–85.

3 Features of the Russian machine tool market

The Russian machine tool industry is a minor machine tool manufacturer in international statistics of machine tool production. According to the findings in the previous chapter, Russia's production only corresponds to 0.6 per cent of world production of machine tools, which gives it a seventeenth place. On the other hand, it is the country with the largest import quota to production. In other words Russia has more or less lost its domestic market to foreign providers. The main features of this market are the subject of this chapter.

3.1 The loss of control over the Russian machine tool market

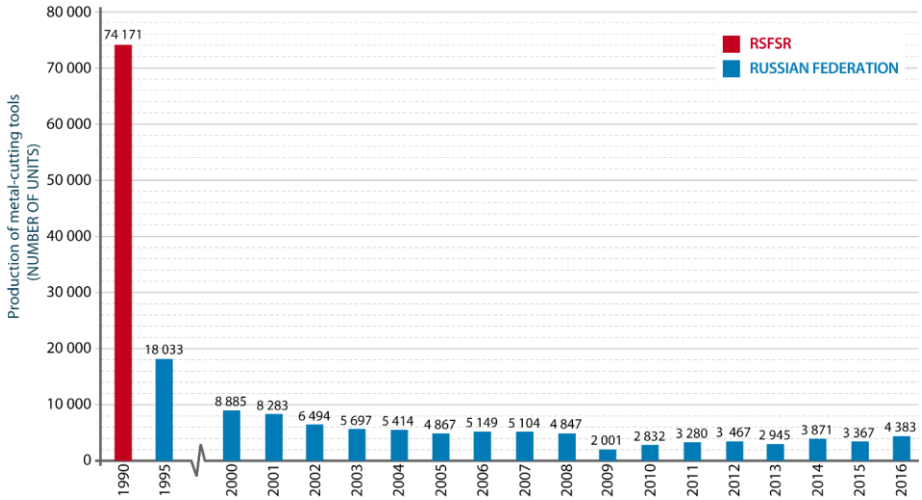
The comparison discussed in Chapter 2, between the Russian machine tool market and other country markets regarding domestic production, import ratio to consumption and trade deficit indicates the dire straits of Russia's machine tool industry. Its long decline began when the Soviet Union, like many other traditional machine tool builders, lost in competiveness with the introduction of NC and CNC machine tools. Although it was by then the world's third largest producer of machine tools, throughout the 1980s the Soviet Union already covered a third of its demand with imported machine tools.[56]

The daughter industries of the Soviet machine tool industry in 1991 were poorly equipped to cope with the economic shocks that followed Soviet disintegration. The market for domestic machine tools in Russia more or less collapsed between 1990 and 2000. According to official Russian data, the production of metal-cutting machine tools between these years shrank by almost 90 per cent. The lowest point of cutting machine-tool production occurred in 2009, when only 2 000 pieces were manufactured, as shown in the bar chart in Figure 2. From then on, until 2016, production more than doubled, to 4 400 pieces. Even so, production in 2016 was less than a fourth of the production in 1995.[57]

[56] The UNIDO Secretariat, *op. cit.*, tables on pp. 52, 90–91, and author's own calculations. Demand is here defined as: production + import – export.

[57] Egorenko, *op. cit.*

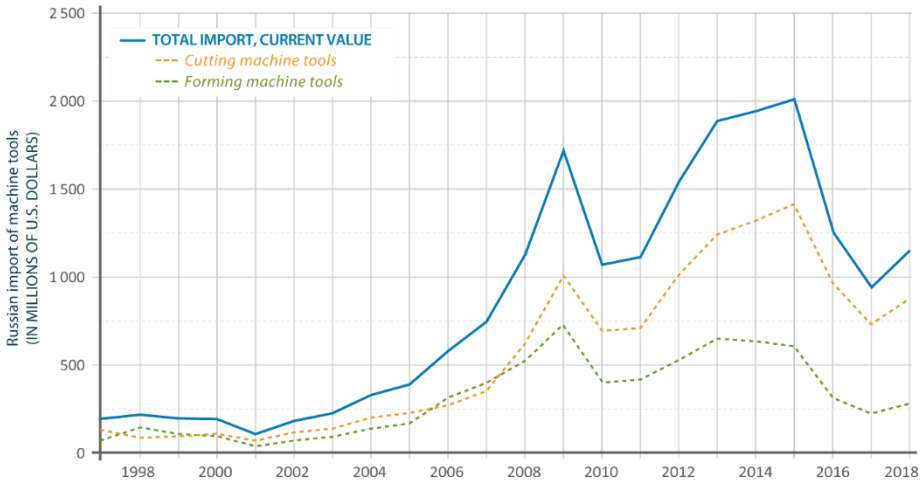
Figure 2: Manufacture of metal-cutting machine tools in Russia 1990–2016 by quantity[58]



However, Russia's demand for machine tools as such did not vanish. Based on trade statistics from the United Nations' Comtrade database, the line chart in Figure 3 demonstrates the dynamics of Russian import of both cutting and shaping machine tools from 1996, the first year for which Russian data are represented. Although the figures represent different kinds of data, the shapes of the line graphs in Figure 3 bear no resemblance to the bar chart over the number of domestically produced cutting machine tools in Figure 2. The volatility in imports is not matched by the steady decline in domestic production followed by the slow upturn in output after 2009.

[58] Regiony Rossii. Sotsialno-ekonomicheskie pokazateli, Rosstat, different years, *www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/publications/catalog/doc_1138623506156*

Figure 3: Russian import of machine tools, 1996–2017, millions of U.S. dollars, current value[59]



On the other hand, there is a much closer resemblance between Russian import in Figure 3 and the line chart over world machine tool consumption and production from Figure 1 in the previous chapter. As these two figures demonstrate, Russian import of machine tools is a fair approximation of its consumption pattern, which apparently follows the ups and downs of the global patterns of machine tool consumption relatively closely.[60] This also means that the demand side of the Russian machine tool market is essentially formed by the same forces that shape the market conditions at the global level. The most obvious correlation is the long upturn from 2003 to 2013 or 2014, including the temporary decline following the financial crisis 2007–2008. It is also worth noting that the Russian upturn from 2011 is more similar to the Asian course of development (and then especially China's) than the European trend, where demand has levelled out.

According to the Russian Ministry of Industry and Trade, the main cause of the decrease in demand in 2015–2016 was the fall in purchasing power within the purchasing industries, due to the changes in Russia's economic and macroeconomic situation.[61] As global data on machine tool consumption and production

[59] DESA/UNSD, United Nations Comtrade database, *https://comtrade.un.org/data*; Gardner Research, *www.gardnerweb.com/articles/list/223*.

[60] A caveat might be in place here, as the data series are not entirely commensurable. Comtrade data are in current dollar value, and Gardner Research data are in constant or real dollars. Some of the difference in values follows from the two line graphs over total import in Figure 3. The values of the two graphs are different, but the general shapes of the curves are basically the same.

[61] Minpromtorg, *Strategiia* razvitiia, pp. 3, 19.

after 2016 was lacking at the time of writing this study, it was not possible to establish whether the Russian upsurge in import 2017 was connected with a more general global trend or with domestic causes.

3.2 Market demand formation in Russia

As mentioned above, the largest buyers of machine tools in the Russian economy are those industries that the Russian leadership consider to be strategically important: the defence, aircraft, car, and heavy industries, and power engineering, shipbuilding and metallurgy.[62] The main buyer among these is the defence industry, which emerged in tandem with the domestic machine tool industry and therefore came to characterize much of its development during Soviet times.

For the defence industry, a specific factor affecting demand for new machine tools is Russia's State Armament Programmes, which provide the basis for the modernisation of military equipment as well as the rearmament of the Armed Forces. The ambitious State Armament Programme 2011–2020, in particular, stimulated the defence industry's demand for modern machine tools. It also provided some of the necessary means to refurbish and modernise the defence industry's production facilities from 2011 and onwards. The impact of the armament programmes on the machine tool market is discussed more in detail in Chapter 5, which deals with the questions of state interventions and support to the Russian machine tool industry.

3.3 Market demand structure

Russia's dependence on imported machine tools in the mid-2010s, based on their rouble value, amounted to approximately 90 per cent, according to official Russian data. Calculated as the number of imported machine tools, import dependence reached 68 per cent. In 2016, the unit price for imported machine tools amounted to 4.6 million roubles on average, as the average unit price of a domestically produced machine tool equalled 1.2 million roubles. The average price for Russian-made machine tools that went to export corresponded to 3.7 million roubles. [63] According to the Ministry of Industry and Trade, the price differences between imported and domestic machine tools are due to weak competencies in the production of high-technology machine tools.[64] Taken together, this indicates that imported machine tools mostly belong to the high end of the market, while Russian-made machine tools are in the middle or lower end.

Within the cutting machine tool segment, import dependence was a stable 90 per cent. An increasing share of imported cutting machine tools are numerically controlled (CNC); in 2015, this amounted to as much as 84 per cent measured in value

[62] Minpromtorg, Strategiia *razvitiia*, p. 12.
[63] *Ibid*., pp. 3, 19.
[64] *Ibid*., p. 28.

and 63 per cent in units of procured machines. About 73 per cent of imports within this segment are within the high end of the market, with imports from Germany, Japan and Italy.[65]

Within the metal-forming machine tool segment, import dependence in roubles was more than 95 per cent and less than 50 per cent measured in units. The import trend points towards more procurement from the upper end of metal-forming CNC machines; the number of CNC machines has shrunk to 45 per cent of import, at the same time as their cost share has remained at 70 per cent of total import cost.[66]

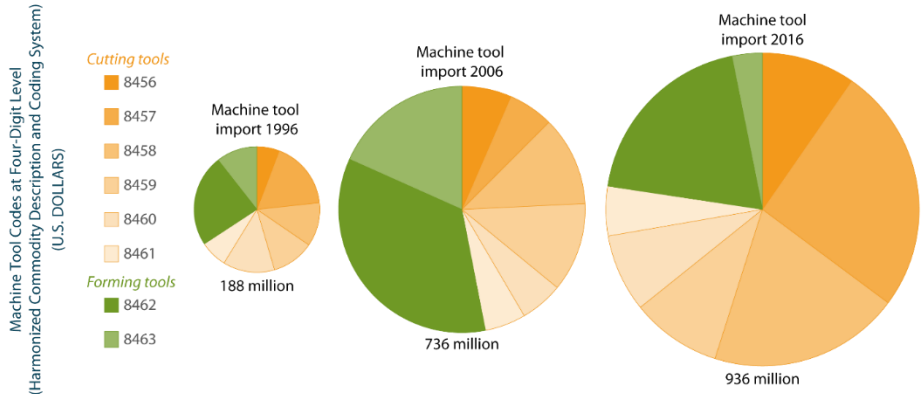
Assuming that Russia's machine tool import is a fair approximation of its market demand, the Comtrade database used in Figure 3 above provides even more data about the composition of Russia's investments in new machine tools. In 1996–2006, Russia's import of machine tools was more or less evenly distributed between cutting tools and forming tools. The share of cutting tools has thereafter increased successively, and in 2016 it amounted to 77 per cent, measured as current dollar value.

Figure 4 shows the distribution of Russian import of machine tools based on the current dollar values in 1996, 2006 and 2016, in accordance with the statistical nomenclature of the Harmonised System, HS. As mentioned in the introduction in Chapter 1.1, this system was first developed by the World Customs Organisation and is widely used in trade statistics. In this case, data has been retrieved from Trade Map, a database under the auspices of the International Trade Centre, ITC, which is a joint development agency of the World Trade Organisation and the United Nations. For a full legend of the four-digit codes used for the different product classes in the pie charts, see Table A:2, in the Appendix.

The pie charts in Figure 4 show that over the twenty years from 1996 to 2016, Russian import of machine tools has become more focused. If import was more evenly distributed in 1996, in 2016 the import of machining centres (code 8457) dominates, followed by lathes (code 8458), and forming machines that work metal by forging, hammering, bending, folding, straightening, flattening, shearing, punching or notching (code 8462). These three product classes equalled 65 per cent of Russian machine tool import in 2016.

[65] Minpromtorg, *Strategiia* razvitiia, pp. 19–20.
[66] *Ibid*., p. 22.

Figure 4: Distribution of Russian import of machine tools in 1996–2016 based on current dollar value[67]



A plausible interpretation of the unit value of a product is that it gives a rough indication of its technology content. Based on this assumption, a high unit value for a certain type of machine tool, combined with a large share in a country's total import of machine tools, probably signals a certain price inelasticity, especially if the imported quantity does not change much from one year to another. In other words, even if the cost increased, the country would basically continue to buy the same quantity of this type of machine tool because of lack of substitutes or alternative suppliers.

Table 4 below shows typical unit values in dollars per metric ton for Russian machine tool import 2014–2017, combined with total import value and quantity in 2017 for all machine tool product classes, according to the ITC Trade Map database. It is worth noting the falling average unit values for almost all types of machine tools 2014–2017, in Table 4. A plausible explanation for this falling trend might be that a weak world market presses prices downwards globally. However, to sort out what is going on in the Russian market, it is much more reasonable to take a closer look at how the composition and internal order of the providing countries have changed over time.

[67] International Trade Centre, *www.trademap.org/tradestat/Country_SelProductCountry_TS.aspx?nvpm=1|643||||8456|||4|1|1|1|2|1|2|1|1.*

Table 4: Value and distribution of Russian import of machine tools[68]

HS Code	Imported unit value, US dollars/metric ton				Imported value in 2017, thousands of US dollars	Imported quantity in 2017, metric tons
	2014	2015	2016	2017		
8456	27 823	23 772	20 767	19 934	130 768	6 560
8457	20 993	17 649	17 260	16 914	270 976	16 021
8458	18 832	17 629	16 089	15 579	225 977	14 505
8459	15 306	13 123	12 253	11 753	90 050	7 662
8460	16 574	19 506	16 063	15 059	108 473	7 203
8461	16 941	17 548	13 188	12 478	54 244	4 347
8462	10 150	8 507	8 270	8 128	234 690	28 873
8463	18 368	19 060	13 623	15 793	42 089	2 665

3.4 Foreign providers

According to ITC data, Russian machine-building companies procured machine tools from providers in 77 different countries between 2008 and 2017. At a country-level, the concentration ratio for the ten largest providers was nevertheless 81 per cent, or, in other words, the ten largest providing countries accounted for 81 per cent of Russian total machine tool import. Another relevant measure is the Herfindahl Index.[69] The inverse of the Herfindahl Index is a numbers-equivalent of seller concentration. The lower this figure, the more the market deviates from a perfect market and approaches an oligopoly market, or if it is close to one, a monopoly market. In this case, the Herfindahl Index is 0.107 and the inverse 9.3. This means that the market was as concentrated as a market with 9.3 equally-sized providers. These figures have also been quite unchanging over time. For instance, calculated for 2017 – the last year for which import data exists – the concentration ratio for the ten largest providers amounted to 80 per cent and the Herfindahl index

[68] International Trade Centre, *www.trademap.org/tradestat/Country_SelProductCountry_TS.aspx?nvpm=1|643||||8456|||4|1|1|1|2|1|2|1|1*.

[69] In this study, the Herfindahl Index is defined as the sum of squared market shares of all providers such that:

$$HH = \sum_{i=1}^{n} \left(\frac{x_i}{x}\right)^2$$

where x_i signifies the n-th provider and x all providers combined.

equalled 0.096, the same as 10.4 equally-sized providers.[70] At country level, the Russian import market for machine tools thus exhibits distinct traits of an oligopoly market for the examined period.

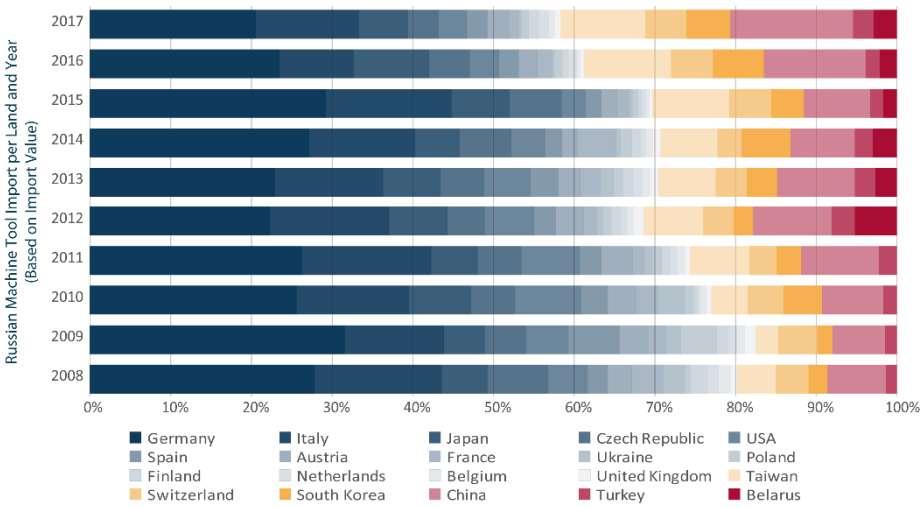
The dynamics of Russia's import market for machine tools 2008–2017 are shown in the stacked bar charts in Figures 5 and 6. These charts illustrate the market share for each of the twenty largest providing countries between 2008 and 2017. Figure 5 shows their market shares according to the imported value. Figure 6 lists the same countries, but displays their market shares according to the imported quantity from each country, measured in metric tons. Altogether, both graphs represent 96 per cent of Russian machine tool import for the entire period.

The order in which the countries appears is the same for both graphs and follows on from a rough partition of all countries into one of three groups. The first fourteen countries to the left in the graphs (Germany to United Kingdom) are considered as 'guardians of the existing liberal world order' and as sceptical or fault-finding observers of Russian domestic and foreign policy. China, Turkey and Belarus are considered as 'current friends of Russia', or as challengers to the present world order. In between are Taiwan, Switzerland and South Korea, which, although they lean towards the first group, can be seen as more neutral or disinterested in the current clash between Russia and the countries from the first group. Admittedly, this classification is very rudimentary, subjective and indefinite. For instance, the classification of Ukraine and Turkey builds on their relations with Russia in 2018, which were diametrically opposite back in 2008. The point here, however, is not to straighten out all the intricacies of Russia's relations with its machine tools providers, but to distinguish between countries that, from a Russian perspective, might be considered as having been reliable long-term providers of machine tools under the political conditions that prevailed in 2018, and countries that are more likely to close off their machine tool export to Russia from one day to another due to different sanction regimes or bilateral political clashes.

Based on import value, Figure 5 identifies Germany and Italy as Russia's dominating providers of machine tools. China, Taiwan and Japan might be considered as challengers, and in 2016–2017 China outperformed Italy. However, the most interesting change 2008–2017 is that the neutral countries, as well as Russia's friends and common challengers of the present world order, have gained market share from those countries that are here considered to be Russia sceptics and preservers of the present world order. In 2008, the combined market share for the first two groups amounted to almost 20 per cent, which had grown to approximately 43 per cent in 2017. The most dramatic growth occurred in 2015 to 2017, when their market share increased by some 13 percentage points.

[70] Based on the author's calculations of ITC data.

Figure 5: Russia's providers of machine tools 2008–2017, imported value in current dollars, 100% stacked bar chart[71]

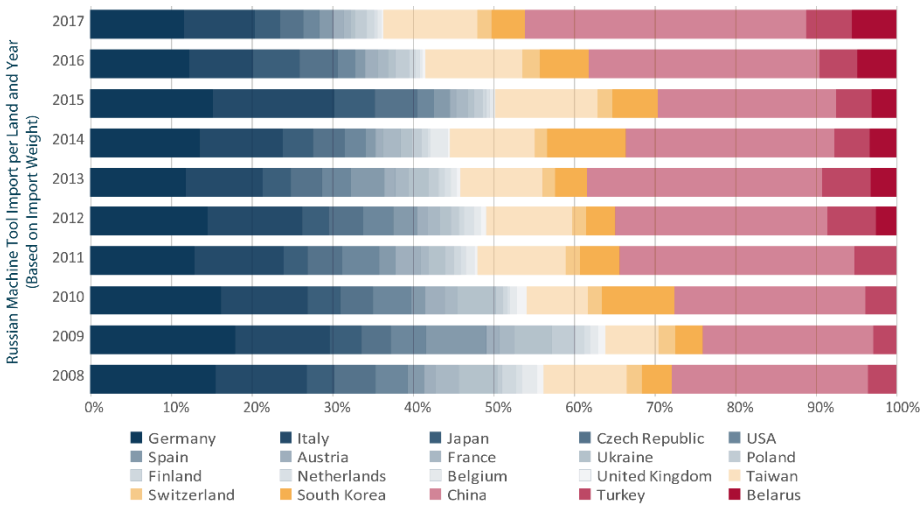


From the late 2000s, Russia has thus diversified its import of machine tools, either voluntarily or as a necessity, due to its deteriorating relationships with the countries in the first group. Yet, in 2017, this group still provided 57 per cent of Russian machine tool imports in the sample based on import value, which seems to be in contradiction to Russia's efforts to become less dependent on foreign suppliers, especially, one might presume, potentially hostile suppliers.

The stacked bar chart in Figure 6 shows this shift even more strongly. Based on the imported quantity, China has become Russia's largest provider, followed – but hardly challenged – by Germany, Italy, South Korea and, eventually, Japan. The market relocation towards friendlier countries appears more distinctly than in the previous graph, especially as regards China. The first group, consisting of Russia's opponents, has shrunk in this chart from 56 per cent in 2008 to 36 per cent in 2017; the most dramatic fall occurred in 2015 to 2017, by 14 percentage points.

[71] International Trade Centre, *www.trademap.org/tradestat/Country_SelProductCountry_TS.aspx?nvpm=1|643||||8456|||4|1|1|1|2|1|2|1|1*; author's own calculations.

Figure 6: Russia's providers of machine tools 2008–2017, imported quantities in metric tons, 100% stacked bar chart[72]



In other words, the quantity of Russian import from potentially unfriendly countries has diminished significantly during the ten years in the sample, at the same time as friendly countries have increased their market share. But this development has come at a cost: as the shift measured in quantity is considerably larger than when the same shift is measured in value, the bets are that Russia has substituted a noticeable share of its import of high-end machine tools from the most advanced machine tool-producing countries for less expensive Chinese, Turkish and Belarusian machine tools. Even if the different purchasing power parities were taken into account, the price difference reveals that these machine tools are closer to the lower or mid-range of the machine tool market. This interpretation is also consistent with the falling unit prices over time, shown in Table 4. Although this development makes political sense, as it increases Russia's room for political manoeuvre and protects it from sanctions, the economic downside is that it hampers Russia's ambition to become a leading industrial country for technologically advanced products such as aircraft, cars and sophisticated arms systems.

3.5 Summing up

The modern machine tool industry is an advanced high technology industry of strategic importance. Access to leading-edge machine tools is often a necessary condition for manufacturing countries to maintain their competitive advantage vis-à-vis other countries.

[72] International Trade Centre, *www.trademap.org/tradestat/Country_SelProductCountry_TS.aspx?nvpm=1|643||||8456|||4|1|1|1|2|1|2|1|1*; author's own calculations.

The Russian conundrum is not only that it has lost its grip on the domestic market. Its deteriorating relations with the leading machine tool manufacturing countries in the world have also increased its dependence on lower and mid-range machine tool manufacturers. This runs counter to its ambition to become a leading industrial manufacturer for high-end and high-technology products with a world market potential that could replace or mitigate its current reliance on gas and oil export.

Whether it is intentional or purely accidental, it therefore seems that, in this case, Russian geopolitical logic trumps market economy logic.

4 Russian machine tool industry structure

The overall impression from Russian sources is that the political consensus in Russia is that it is a matter of national security that the domestic machine tool industry regains its role as a major supplier to the manufacturing industry. It is also a question of national pride.

As the ambition of the Russian government is not to compete with low-end products in a mass production market but to aim for the high-end market segment, the task is difficult. It implies that the domestic machine tool industry needs to bridge the existing technology and quality gaps vis-à-vis leading foreign machine tool providers and become a focal point for technological excellence and technology transfers with relevance for Russia's entire manufacturing industry.

This chapter analyses whether the industry has any prospects, on its own merits, of attaining the role of the primary supplier of machine tools to the manufacturing industry – especially to the defence industry – or if it has reached a point of no return, without any prospects. This chapter centres around the industry structure and the forces that shape, and are being shaped, by it.

4.1 Industry structure: determining the basic rules of competition

Industry structure

An industry structure comprises the number of firms and their size together with entry and exit conditions for the industry. It is the specific structure of each industry that defines the basic rules of competition that all firms operating within a certain industry need to consider.[73] The number and size of firms reflects the opportunities for achieving economies of scale, not least regarding production or research and development. Where scale economies do exist, firms have incentives either to expand internally or via mergers and acquisitions.[74] Industries with prevalent economies of scale tend to gravitate, in general, towards either an oligopoly market or a monopoly market in the long run.

The entry and exit conditions for an industry stem from the forces that collectively shape competition and industry profitability. Common distinctions of these forces

[73] Porter, Michael E., (1981): 'The Contributions of Industrial Organization to Strategic Management', *Academy of Management Review*, 1981 6:4, pp. 609-620, *http://213.55.83.214:8181/Economics/Economy/01731.pdf*, [accessed May 07, 2018].

[74] Hartley, *op. cit.*, pp. 76–77.

include power of buyers, power of suppliers, barriers to entry, or threat of new entrants, the threat of substitute products and the rivalry among existing competitors. These conditions vary from industry to industry, as do average profitability. The strength of each of these five forces can also change, either improving or eroding the attractiveness of an industry'.[75] In essence, 'industry structure, as manifested in the strength of the five competitive forces, determines the industry's long-run profit potential because it determines how the economic value created by the industry is divided – how much is retained by companies in the industry versus bargained away by customers and suppliers, limited by substitutes, or constrained by potential new entrants.'[76] According to economist Michael Porter, the attractiveness of an industry increases if the five forces are weak: 'the weaker the forces collectively, the greater the opportunity for superior performance.'[77]

Industry structure and the machine tool industry

As discussed in Chapter 2, economies of scale do not appear to be overly determining within the machine tool industry. Even in countries with a long tradition of machine tool manufacturing, a large number of small- and medium-sized companies, SMEs, usually coexist with a few large companies.

As a rule, economies of scale are stronger for low-cost production of rather identical commodity-type machines at the low end of the market. The basis for competition within this segment inclines towards price competition. Price competition is especially destructive to a company, since it transfers profits directly from an industry to its customers.[78]

The high-cost segment of the machine tool industry, on the other hand, inclines towards a monopolistic market.[79] In contrast to a monopoly market, where one firm *is* the industry, monopolistic markets are distinguished by a large number of relatively small firms. Whereas a monopoly market is characterized by entry barriers, entry to a monopolistic market is free, ensuring normal profits in the long run.[80]

In a monopolistic market, competition is based on quality, design and service, rather than on price. Products from one firm are therefore not perfect substitutes for products from another. At least in the short run, this gives some monopoly power

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75 Porter, *On Competition*, p. 84.
76 Porter, Michael E. (1979): 'How Competitive Forces Shape Strategy', *Harvard Business Review* 57, no. 2, March–April 1979, pp. 137–145.
77 *Ibid.*
78 Porter, Michael E. (2008): 'The Five Competitive Forces that Shape Strategy', *Harvard Business Review* 86, no. 1, January 2008, pp. 78–93.
79 Hartley, *op. cit.*, p. 79.
80 Tisdell, Clem, and Hartley, Keith, (2008): Microeconomic Policy – A New Perspective, Edward Elgar Publishing Ltd., Cheltenham, U.K., p. 192.

to an individual firm to influence the market price of its own products. Such non-price competition is less likely to erode profitability as long as rivals do not compete on the same dimensions. If they were to, the result would be zero-sum competition, where one firm's gain would be another firm's loss, which would drive down profitability. For example, a distinguishing feature for European machine tool builders, which are essentially serving a monopolistic market, is the high service content of the sales price. In some companies, the service content can go as high as 40 per cent.[81]

Lastly, with a large number of firms, market knowledge in a monopolistic market is imperfect. In order to reach out to potential buyers, firms usually spend large resources on advertisement and promotion. Under monopolistic competition, these costs often constitute a substantial part of the firm's total cost.

The machine tool industry and the forces that shape competition

How then does the collective strength of the five forces mentioned above pertain to the machine tool industry? Within the high-end market segment – which is the most interesting segment from a Russian perspective given the government's view on Russian economic development – the accumulated experience from the high-cost European machine tool industry indicates that it is a highly competitive environment with limited profitability.

According to CECIMO, buyers of products from the European machine tool industry cover a wide range of sectors, of which the most important are the automotive – covering approximately one-third of the market – and mechanical engineering industries. Other major customers are the aerospace and aeronautics industry; manufacturers of railway vehicles, and of power generation and distribution equipment; the medical equipment and optics industries; shipbuilding; watch-making; and the defence sector. Within the automotive industry, there is a growing trend towards increased concentration of a few buyers, the so-called oligopsony buyers, which also leads to an increased cost sensitivity. This development undermines the bargaining position of the European machine tool builders, in particular the SMEs, vis-à-vis their customers.[82]

For the same reason, the bargaining position of the SME-dominated European machine tool industry vis-à-vis its suppliers is weak, as the supplier group is more concentrated and it serves other and larger customer groups as well. In certain key areas, such as in electronic controllers, the source of supply has even turned into a

[81] Gümüşdere, Gökalp, Gerczynski, Marek (eds.) (2011): 'Study on the competitiveness of the European machine tool industry', CECIMO, *http://www.cecimo.eu/site/fileadmin/Publications/Studies_and_Reports/Study_on_Competitiveness_of_the_European_Machine_Tool_Industry_-_December_2011.pdf*, [accessed May 14, 2018], p. 40.

[82] Gümüşdere and Gerczynski, *op. cit.*, pp. 18–19.

single monopoly, or oligopoly, threatening the profitability of the machine tool industry by keeping input costs high.[83]

The threat from new actors to the high-end market segment that European machine tool builders serve is limited. This follows from the fact that the intended machine tools for this market segment are capital-intensive investment goods, whose high value-added follows from the manufacturer's high level of technological know-how. Nevertheless, new entrants that are technologically well-equipped might become a threat to European machine tool companies' market share. The most obvious example is the rise of new machine tool builders in emerging Asian countries that are undergoing rapid industrialisation. These enterprises are usually backed up by public finances and protected home markets. Their entry costs are usually lowered even further by the fact that they have built their technological knowledge by copying. Their appearance is underpinned by the emergence of a large number of engineering service providers across the globe that are ready to transfer know-how to new entrepreneurs, while in China, the government has provided strong financial support for research and development in machine tool building.[84]

Given the European machine tool industry's dominant SME structure, the threat from existing competitors is related to larger, predominantly Asian companies. Due to their size and close access to the large Asian markets, these companies are more prone than European manufacturers are to engage in price competition. Their size also implies that their bargaining power versus suppliers and buyers is stronger. State-backed competitors from non-European countries are also strongly committed to obtaining market leadership, a goal that is linked to the overall economic policies of their governments.[85]

The main threats for the European machine tool industry regarding substitutes generate from changes in the downstream markets. For instance, car makers increasingly use composite materials in their vehicles. Likewise, the shift to battery-powered cars may decrease the number of mechanical parts in cars. Additive manufacturing represents a more specific and direct substitute, as it offers new methods of metal processing.[86] These threats are not unique to the high-end segment of the machine tool market, but affect the low-end segment as well.[87]

[83] *Ibid*., p. 23.
[84] *Ibid*., p. 24.
[85] *Ibid*., p. 26.
[86] Gümüşdere and Gerczynski, *op. cit.*, p. 26.
[87] *Ibid*.,

4.2 Structure of the Russian machine tool industry

Industry structure

In the late 2010s, Russia's machine tool industry accounted for 0.02 per cent of GDP. This is a low figure compared to some of the leading producing countries: China (0.2 per cent), Japan (0.33 per cent) and Germany (0.37 per cent).[88]

It is difficult to establish how many enterprises are active within the Russian machine tool industry. Allegedly, in 2011 there were 46 enterprises producing metal-cutting machine tools in Russia and another 25 factories specializing in forging or pressing equipment. Although beyond the scope of this report, but nevertheless closely related to the machine tool industry, in 2011 there were also 29 manufacturers of cutting, measuring and bench mounting tools,[89] as well as 7 research institutes and 45 design or engineering bureaus specialised in machine tool design and research.[90] In the Russian language, all these closely inter-connected industries are frequently referred to collectively as the machine tool and tool industry, *stankoinstrumentalnaia promyshlennost*. All of these categories are represented in the Russian National Association of Machine-tool and Tool Manufacturers, Stankoinstrument.[91] In 2018, the Stankoinstrument membership register listed 143 members, which means that the structure was relatively stable in the 2010s.[92]

According to the Russian Ministry of Industry and Trade, there were 80 domestic machine tool firms in total, and 29 tool companies, in 2017.[93] The metal-cutting segment of the industry encompasses 56 companies. The output of its top six companies accounted for 54 per cent of Russia's domestic production, indicating a rather modest concentration ratio.[94] The metal-forming segment consisted of 24 companies. The concentration of this segment is much higher; the top three producers accounted for 65 per cent of Russia's total output of metal-forming machine tools in 2017.[95] Still, at the aggregated level, the privately-owned Stan Holding Company claimed in 2018 that its seven subsidiaries together produce over half of

[88] Minpromtorg, *Strategiia razvitiia*, p. 14.
[89] According to statistical classification code 25.73.40 in the OKPD-2, interchangeable tools for hand tools, whether or not power-operated, or for machine tools.
[90] Vilde, Tatiana (2011): 'Skovannye odnoi tsepiu', Ekspert Severo-Zapad, No. 22 (518), *http://expert.ru/northwest/2011/22/skovannyie-odnoj-tsepyu/*, [accessed June 05, 2018]
[91] In Russian: 'Rossiiskaia assotsiatsiia proizvoditelei stankoinstrumentalnoi produktsii Stankoinstrument'
[92] *http://stankoinstrument.ru/alfavitnyy_ukazatel_pr*, [accessed June 04, 2018]
[93] Minpromtorg, *Strategiia razvitiia*, p. 26.
[94] Minpromtorg, *Strategiia razvitiia*, p. 21.
[95] *Ibid*., p. 23.

all Russian metal-cutting and metal-forming machine tools, corresponding to five per cent of the total domestic market.[96]

Other distinguishing features of Russia's machine tool industry during these years have been: the domination of small- and medium-sized companies, those with less than 250 employees; the lack of specialisation among the larger companies involved in cutting machine tool building; the lack of an industry leader; and the presence of a large number of companies that have mastered only parts of the production cycle.[97]

Geographic distribution

Given Russia's vast landmass, geography is a relevant factor contributing to the industry's structure. Table 5 presents the regional distribution of machine tool companies, as well as their production in numbers of units produced, and regional revenue from machine tool production. Data in the table come from the Unified Interdepartmental Information-Statistical System, UIIS, which is run by Ministry of Digital Development, Communications and Mass Media.[98] Crimea has been included in the table, as Russia considers that it has been an integral part of its territory since 2014. This claim is not approved by Ukraine and is disputed within the international community. In 2015, Crimea ceased to be a federal district in its own capacity and was incorporated into the Southern Federal District of the Russian Federation.

[96] OOO Stan (2018): O kompanii [online], *www.stan-company.ru/about/o-kompanii/*, [accessed June 13, 2018]

[97] Minpromtorg, *Strategiia razvitiia*, pp. 26-27.

[98] UIIS in Russian: *EMISS* or *Edinaia mezhvedomstvennaia informatsionno-statisticheskaia sistema.* The Ministry of Digital Development, Communications and Mass Media (until 15 May 2018 Ministry of Telecom and Mass Communications), in Russian: *Ministerstvo tsifrovogo razvitiia, sviazi i massovykh kommunikatsii Rossiiskoi Federatsii*.

Table 5: Regional distribution of medium-sized and large machine tool companies and machine tool production 2014–2016.[99]

Federal district	Machine tool companies			Machine tool production (no. of units)			Revenue (thousands of roubles)
	2014	2015	2016	2014	2015	2016	2017
Central	23	27	25	1 908	1 662	1 950	2 546 884
North-West	7	8	8		71	365	295 412
South	6	3		814	745	834	
North Caucasus	1						
Volga	16	15	16	857	631	792	4 035 083
Ural	4	3	5	2	18	158	
Siberia	3	2	3	290	240	284	
Far East							
Crimea	1	1					
Total	**61**	**59**	**57**	**3 871**	**3 367**	**4 383**	**7 372 688**

Comments: In 2014–2015, Crimea was considered a federal district in its own capacity. Since 2016, it has been incorporated in the South Federal District. Russia's annexation of Crimea is not legally recognized.

UIIS data are apparently not entirely commensurable with data from the Ministry of Industry and Trade, nor are they complete. However, the overall picture is more or less consistent with the view of the Ministry of Industry and Trade.[100] The most important production regions are the Central, Volga and South Federal Districts. According to the Ministry of Industry and Trade, some important key actors are located in the North-West and Siberia Districts.

There is no correlation between the geographic location of manufacturers of metal-cutting machine tools and of producers of forging and pressing equipment. The leading regions for metal-cutting machines are the Republic of Bashkortostan and the Moscow, Ulianovsk and Lipetsk oblasts. The principal producers of forging and pressing equipment are located in Altaiskii krai, as well as Voronezh, Moscow and Orenburg oblasts.[101]

There is also no strong geographic correlation between the machine tool industry and its suppliers and buyers. The most important research institutes and centres for

[99] Rosstat, Regiony Rossii. Sotsialno-ekonomicheskie pokazateli, different years, *www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/publications/catalog/doc_1138623506156*; Edinaia mezhvedomstvennaia informatsionno-statisticheskaia sistema (EMISS), *https://fedstat.ru/indicator/33407*; EMISS, *https://fedstat.ru/indicator/57710*.

[100] See Minpromtorg, *Strategiia razvitiia*.

[101] Minpromtorg, *Strategiia razvitiia*, pp. 32–33.

the industry are concentrated in Moscow. Component and tool suppliers serve other manufacturing industries as well, and are therefore not dependent on the geography of the machine tool industry.

The principal machine tool buyers – the defence, shipyard and aircraft industries as well as all other machine-building industries – are concentrated in different regions. For instance, the shipyard industry has it main centres in the Leningrad and Arkhangelsk oblasts. The most important defence industrial regions are the Sverdlovskaia, Omskaia, Tulskaia and Vladimirskaia oblasts.[102]

4.3 Impact of the competitive forces on the Russian machine tool industry

Buyers

Although all of Russia's strategic industries are associated with a large demand for machine tools, it is the defence industry, in its capacity as the principal buyer, which has put its mark on the development of the domestic machine tool industry. Its high degree of specialisation and strong orientation towards the defence sector has inhibited the Russian machine tool industry from expanding into the more diversified civilian metal-working industry at large. In the 2010s, the civilian market segment was further weakened, by falling production and the completion of large public projects within the Russian economy. In comparison, machine tool industries in China, Japan, Germany and the USA are by tradition more agile in working with civilian customers.[103]

The major buyers' demand for machine tools is to a large extent driven by the government's strategy to modernise Russian industries across several key sectors: power generation, transport, defence, automotive, aerospace, shipping, and agriculture. In this context, Russia's machine tool builders' bargaining power is at its greatest when there are no alternatives to non-standardised, nor tailor-made, machine tools produced by a single and highly specialised domestic manufacturer. However, when given the choice, the procurement patterns of Russia's metal working industries over the last decades demonstrates that they prefer foreign-made to domestic machine tools. As a rule, the competiveness and bargaining position of the domestic machine tool industry are both very weak. It remains to be seen whether or not the Russian government's recent import substitution policies, which were instigated to counter the sanctions regimes that have been raised against Russia since 2014, might strengthen the domestic machine tool industry's bargaining position and competiveness in the long run.

[102] Minpromtorg, Strategiia razvitiia, p. 33.
[103] *Ibid*., pp. 13, 41.

Suppliers

On the supply side, the competiveness of the Russian machine tool industry is shaped by its access to components and tools; to credits and investments; skilled workers; and research and development. Well into the 2010s, they still have an inhibiting impact on the machine tool industry's competitiveness.

As a group, Russian component suppliers provide components for the entire machine-building industry, of which the machine tool industry is just a smaller part. The component industry consists of fewer firms than the machine tool industry, which makes it more concentrated. Both these properties theoretically mean that the component industry has more bargaining power than the machine tool industry. On the other hand, vis-à-vis foreign providers, the competiveness of Russian component makers is low in all technology segments. In 2017, about 40 to 70 per cent of the component value in Russian-made metal-forming machine tools still consisted of imported components, which probably has a negative impact on the bargaining power of the Russian component industry vis-à-vis its customers.[104]

In Russia in 2017 there were approximately ten companies producing CNC controls. Some of the more prominent were T-Platformy, Balt-Sistem, Mekhatronika and Mikros. Their production is focused on universal machine tools. For CNC controls with higher reliability and accuracy, Russian machine-tool makers have to turn to the leading producers in Japan, Germany and the USA.[105]

As for drive assemblies and systems, there were 16 component suppliers, including NTTs Privodnaia tekhnika, Balt-Sistem and VEMZ. Their production is more all-purpose than specifically aimed at the machine tool industry, as this market segment is too small to enable profitable manufacturing of specialised components. Again, the technology and quality levels do not allow these component suppliers to compete with leading providers from Japan, Germany and the USA.[106]

Compared to the machine tool and component industries, the tool industry in 2017 had achieved a somewhat better position, although the differences were relatively small. In money terms, about 85 per cent of cutting tools made in Russia are carbide tools, of which half are designed for milling. Import dependence was still 60 per cent, due to the low level of technology and the small selection of different models. Russian tool makers also lack a tradition of working together with their clients, while foreign tool suppliers have built up broad networks of trade representatives and storehouses all over Russia.[107]

A factor of different character on the supply side and that affects the machine tool industry is its access to financial capital. Sanctions and the weakening of the rouble

[104] Minpromtorg, *Strategiia razvitiia*, p. 29.
[105] *Ibid*., pp. 29–30.
[106] *Ibid*., p. 30.
[107] Minpromtorg, *Strategiia razvitiia*, pp. 31–32.

since 2014 have degraded Russia's access to international financial markets and tightened credit conditions on the domestic financial market. Simultaneously, fears that the strategic industries have become saturated with foreign-made machine tools might also have caused pessimism over future demand, dissuading private business from investing.[108]

The lack of skilled white- and blue-collar labour is another persistent supply side issue. In 2015, the sector employed 9 500 people whose productivity was less than 800 000 roubles – just 7 per cent of labour productivity per employee compared with the German machine tool industry, according to the calculations of the Ministry of Industry and Trade. Given the low average salary –25 600 roubles in 2016 – the industry remains less attractive than many other sectors of the Russian economy.[109]

Finally, the combined deficit of skilled labour and investments negatively affects all R&D activities related to machine tool and tool development. The earlier well-developed network of institutes of machine tool R&D has shrunk to three active entities: MGTU Stankin, MGTU im. Baumana and OAO ENIMS. The tool industry, for its part, relies solely on the R&D tooling institute OAO VNIIINSTRUMENT. All four institutes are located in Moscow. In other parts of Russia, the R&D competence is scattered across individual departments and centres. Nor does the industry's low profitability give companies enough leeway for forward-looking company-based R&D; due to financial constraints, they focus their R&D efforts on modernising existing and proven designs.[110]

New entrants and entry barriers

Unlike the European machine tool market, the entry barriers to the Russian market have in most cases not been strong enough to prevent well-established foreign machine tool companies from expanding their sales in Russia at the expense of the domestic industry. There are several factors behind this development.

First, Russian machine tool technology has been lagging behind at least since the 1970s. As a rule, the industry has traditionally specialised in general application machine tools and left the segment for advanced machine tools underdeveloped. It has also made the same mistake as many other advanced machine tool industries, in that it was late in applying the new CNC technology. When given the opportunity, the most advanced parts of Russia's machine industry with export potential therefore switched to buying foreign machine tools. For them, if they were to remain competitive within their own line of business, it was not an option to continue

[108] *Ibid*., pp. 13–14.
[109] *Ibid*., pp. 27–28.
[110] *Ibid*., p. 25.

to produce their products on machine tools based on technology that was by then outdated by at least thirty to forty years.[111]

Second, foreign suppliers are usually able to offer their customers better terms on their hire purchase agreements than Russian machine tool companies. This is because they have access to short-term bank loans with significantly lower interest rates, through the banking system in their home countries, than Russian machine tool producers do. High interest rates, large collaterals and short pay-back terms through the Russian banking system mean that it might even become unprofitable for a Russian metal-working company to invest in a Russian machine tool.[112]

Third, Russian defence companies in particular have been pushed by the rigid framework of the state budgetary system to spend any received state funding for capital investments as fast as possible. This is because funding is usually late and they have not been allowed to roll it over into the next budgetary year. To handle the situation, most companies have therefore preferred to buy machine tools off the shelf, when given the opportunity. However, for the same financial reasons discussed above, Russian manufacturers are unable to build up stocks of finished production due to the high interest rates and large collaterals. The ineffectiveness of Russian state funding of capital investments combined with a non-competitive banking system thus impels the defence companies to turn to foreign suppliers from whom they can buy off the shelf.[113]

Fourth, given the complexity of modern production, many machine-building companies no longer have the resources or technical competence themselves to plan, build or start up new production equipment. It is therefore not uncommon in capital projects that the customer either lets the original equipment manufacturer undertake this work or outsources it to a system integrator that specialises in bringing different component subsystems together into an integrated production line. The Russian market is no exception to this but has followed the general trend. However, system integrators operating in Russia usually prefer to work with foreign machine tool manufacturers. This is because a large share of the revenue for a system integrator emanates from resales of equipment. By and large, foreign machine tool builders are able to offer better economic terms for system integrators working with their products than Russian producers can, since they are backed by a more competitive financing system.[114]

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[111] Mekhanik, Aleksandr (2014): 'Kto sdelaet russkii shpindel', Ekspert Online, No. 28 (907), 7 July, *http://expert.ru/expert/2014/28/kto-sdelaet-russkij-shpindel/*, [accessed Sep 28, 2015]

[112] Avdeeva, Kseniia (2016): 'My proigryvaem svoi vnutrennii rynok', Svobodnaia Pressa, 15 Sep, *https://svpressa.ru/economy/article/156534/*, [accessed June 21, 2018]

[113] Mekhanik, Aleksandr (2014): 'Bez svoikh cherviakov ne oboidemsia', Ekspert Online, No. 37 (914), 8 Sep, *http://expert.ru/expert/2014/37/bez-svoih-chervyakov-ne-obojdemsya/*, [accessed Sep 30, 2015]

[114] Mekhanik, Aleksandr (2013): 'Stanok dlia novogo uklada', Ekspert Online, No. 7 (839), 18 Feb, *http://expert.ru/expert/2013/07/stanok-dlya-novogo-uklada/*, [accessed Sep 30, 2015].

On top of this, emerging Asian manufacturers, with Chinese companies at the forefront, are probably a bigger challenge for Russia's machine tool industry than for their European counterparts. In due time, these firms will probably be able to compete on the Russian market not only on price but on quality and technology. Contrary to European firms, Russian companies lack the financial capacity to build competitive local brands in Asia and bring competition there. Moreover, Russia's technology superiority is more modest and deteriorating due to lack of technology development.

Still, some entry barriers have been strong enough to protect the Russian machine tool industry from being totally obliterated. The first of these regards the most advanced machine tools that are covered by the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies.[115] In light of Western sanctions in place since 2014, this circumstance has caught the attention of the defence industry, the largest machine tool buyer. Its reaction has been to demand extensive support for the domestic machine tool industry, to hedge the risks regarding access to these kinds of machine tools in the future.[116]

Russian machine tools are also a first choice for solving non-standardised production problems within the defence, space and nuclear industries. In such cases, it would not even be possible to buy the necessary equipment from abroad. To produce such equipment, a potential supplier would need access to the actual restricted production facility and to technical and other data that many countries, including Russia, consider to be too sensitive from a commercial or military point of view to share with foreign entities.[117]

Existing competitors

Contrary to the devastating competition from foreign machine tool suppliers, competition between Russia's traditional machine tool companies is generally weak, or even non-existent. Certainly, the domination of the Stan Holding Company, and the modest to strong concentration within both the metal-cutting and metal-forming segments at gross level that characterized the mid-2010s, are possible indications of an emerging oligopoly market structure.

However, the eighty or so companies that make up the entire industry usually offer a product mix that is as specialised as it is short and narrow. By and large, Russian

[115] See Wassenaar Arrangement Secretariat (2018): List of Dual-Use Goods and Technologies and Munitions List, vol. II, December 2018, *www.wassenaar.org/app/uploads/2018/12/WA-DOC-18-PUB-001-Public-Docs-Vol-II-2018-List-of-DU-Goods-and-Technologies-and-Munitions-List-Dec-18.pdf*, [accessed December 17, 2018], pp. 25–31.

[116] Mekhanik, 'Stanok dlia novogo uklada'; Eurasian Economic Commission Department of Industrial Policy (2014): Informatsiia o rezultatakh analiza sostoianiia i razvitiia otrasli stankostroeniia v gosudarstvakh-chlenakh TS i EEP, Moscow, [accessed December 17, 2018], p. 19.

[117] Mekhanik, 'Bez svoikh cherviakov ne oboidemsia'.

machine tool manufacturers usually occupy different market niches. Therefore, they typically complement each other to a larger extent than they engage in direct competition. The Ministry of Industry and Trade even noted in 2017 that there were market niches void of Russian manufacturers.[118] The Russian share of the domestic machine tool market is thus inherently monopolistic, as things stand now. Whatever competition there may be is more based on non-price competition than on price differentiation.

In the mid-2010s, several foreign manufacturers established their own assembly lines and some component production in Russia, in order to become 'Russian'. Localised production close to one's customers might bring a competitive edge, but in this case it was also a reaction to changes in Russia's legislation, which imposes higher demands on local production to qualify for contracts financed by government funds. Although this development might sharpen the competitive environment, it will not bring what Russian authorities want most: technology transfer to local manufacturers from leading global machine tool companies. Some technology transfer will certainly take place, but foreign companies have little incentive to give away core competences to Russian business partners that, at the end of the day, as a worst case scenario, might become their competitors.[119]

Substitutes

The threats to the Russian machine tool industry from direct and indirect substitutes are not unique to Russia. With the possible exception of a few local variations, they are basically the same for the entire industry. The permanent development of substitute materials for metal, the emergence of additive manufacturing and the shift towards even more advanced machining centres are examples of shifting paradigms and ruptures that already impinge on the volume and composition of customer demand. Some machine tool market niches might shrink, or disappear, while other market opportunities emerge. The companies that will come out on top from these challenges will probably those that are able to diversify their product range and invest in new technologies. In this way, they will be in a much better position to avoid over-reliance on one product group and to meet customer demand for machining more accurate parts and processing new materials.[120]

In Russia, the industrial community is aware of the challenges ahead on the machine tool market. The existence of a core scientific community and on-going research on, for instance, new materials and additive manufacturing implies a good starting point for the future. However, the generally poor financial shape of Russia's machine tool firms in combination with the poor effectiveness of its financial

[118] Minpromtorg, *Strategiia razvitiia*, p.4.
[119] Khodarenok, Mikhail (2017): 'Vy ne stankostroiteli, a kruzhok iunykh pionerov', Gazeta.ru, 9 Sept, *www.gazeta.ru/army/2017/09/14/10889198.shtml?updated*, [accessed June 28, 2018].
[120] Gümüşdere and Gerczynski, *op. cit.*, p. 26.

sector are serious constraints to Russian R&D and a threat to the necessary adaption to probable changing market conditions.

4.4 Summing up

At first glance, the overall structure of the Russian machine tool industry does not differ considerably from other machine tool industries in the world. It is a moderately concentrated, mostly monopolistic industry dominated by SMEs. However, the market forces that shape competition in Russia differ to a large extent from those that shape the European machine tool market. This is important to note, as the Russian government considers the European machine tool market as a possible model for a future Russian machine tool market.

In Russia, the industry structure and the rules of competition work against the domestic machine tool industry. Under these conditions, it has few prospects for long-term profitability. Its added value from machine tool production is constantly exposed to the risk of being bargained away from the industry by customers and suppliers alike, or constrained by foreign competition, both in the low-cost and high-tech market segments. This explains why it has not recovered since the economic collapse in the early 1990s, in spite of a long-standing surge in demand within Russia's strategic industries, a demand cycle that has followed most global peaks and troughs in machine tool consumption at least since the early 2000s.

5 State support of the Russian machine tool industry

The above examination of the global machine tool industry, and of Russia's domestic market and the structure of its machine tool industry, makes it hard to see how the industry could create more favourable market conditions through its own efforts. The only actor left with a potential impact, then, is the Russian government. This chapter explores to what extent the government is interested in the domestic machine tool industry and how it views the industry's role in the Russian economy. It also looks more closely at how the Russian government intervenes in the machine tool market in order to strengthen the competitiveness of the domestic industry and – most importantly – whether or not these measures have proven to be effective.

5.1 State policies and support – remedies for an imperfect market?

State interventions and the market

The public sector's interaction with the economy usually plays a significant role alongside private decisions on how the resources within an economy are used, put to work, or consumed. Its interference can be sorted into two broad categories. First, it is a significant economic actor in its own capacity. Being a major or the only legal buyer of certain goods and services sometimes gives it substantial market power. Second, as a policymaker, it interferes extensively with all other economic actors. Its interference takes place either directly, through targeted policies, or indirectly, since policies within a certain field might result in unintentional consequences for other parts of the economy.[121] Its involvement is neither inherently good nor inherently bad for industry profitability. It tends to vary from case to case and from one policy to another.[122]

Government interventions are often explained or justified in terms of market disequilibria or market failure. On behalf of the public interest, governments are often expected to intervene in order to reduce market imbalances, provide public goods or correct externalities. Among others, the so-called Austrian school of economics makes a strong case against state intervention; an economy is never in equilibrium,

[121] Tisdell and Hartley, *op. cit.*, p. 19.
[122] Porter, 'The Five Competitive Forces that Shape Strategy' pp. 78–93.

and due to imperfect information, no one, especially not politicians nor bureaucrats, has sufficient knowledge to judge which form of market structure is the most efficient for meeting future consumer demand.[123]

Ideally, governments should restrict themselves to only undertaking activities that have a comparative advantage over private solutions. In reality, this is hardly the case, given the whole range of any government's activities and the degree of interference at all levels in society. From a microeconomic standpoint, the most interesting issues are therefore the costs and benefits associated with each type of intervention and whether or not it would be possible to obtain the desired economic outcome at lower cost, with a different policy, or with private actors.

State interventions and the machine tool industry

The strategic nature of the machine tool industry usually motivates a government to take a strong interest in the industry's present condition and its potential future position in all countries where the sector is represented. In countries like Russia, where the defence sector is the most important buyer of machine tools, state involvement might even be decisive for the industry's structure and market performance. In such countries, the machine tool industry is at least as reliant on government military procurement plans as the domestic defence industry is. This dependence on the public sector creates incentives for the machine tool companies to join forces and lobby the government for such favourable policies as contracts under soft budget constraints, entry restrictions for foreign companies and state funding for industrial development programmes.

Consequently, machine tool firms often operate in a fairly political market place. Such markets are dominated by governments, political parties, bureaucracies and other interests groups. Public choice analysis explains the behaviour in political markets of these groups in terms of their self-interest and exchange in the political process, *i.e.* the formulation and administration of public policy.[124] In public choice analysis, the outcome of government policy choices is therefore interpreted as the result of a bargaining process between self-interested agents associated with the specific market.

In most countries, industrial policies aimed at the machine tool industry have primarily focused on R&D promotion and public procurement as well as support for restructuring efforts and modernisation plans. Government intervention rarely entails state ownership, apart from in centrally-planned economies and some developing countries.[125] Probably the best known example is that of Japan, where company strategies – in this case combined with policies conducted by the Japanese

[123] Tisdell and Hartley, *op. cit.*, p. 26; Hartley, *op. cit.*, p. 82.
[124] Hartley, *op. cit.*, pp. 162–163.
[125] The UNIDO Secretariat, *op. cit.*, p. 13.

Ministry of International Trade and Industry, MITI – successfully enabled a previously inferior machine tool industry to reach a global leadership position within the course of a few decades.[126]

5.2 Russian policies towards the machine tool industry

In Russia, it is normally the Ministry of Industry and Trade that takes the main responsibility for the design and implementation of industrial policies. Other ministries and government agencies participate according to their specific powers and jurisdictions. The state's interest in the machine tool industry is a consequence of its intimate association with Russia's other strategic industries.[127]

As the defence industry is the main buyer of machine tools, there is a strong, although indirect, link between the machine tool industry and Russia's national security interests, which are outlined in its hierarchic corpus of security-related doctrines. These doctrines form the basis for the orientation of the State Armament Programmes, which set the strategic goals for the domestic defence industry and, in the end, their investment needs, including procurement of machine tools: which kind of machine tools to procure, in which quantities and during which time period.

In theory, the state has several levers at its disposal for formulating policies for the machine tool industry. Some of these are applicable to other industry branches and are generic: they include export and import control regimes; export promotion; state support for innovations and R&D; promotion of or prohibition against foreign direct investments, or partnership formations with foreign entities; and so on. Others are more particular and related to the industry's semi-military role in the Russian economy: the volume and orientation of Russian military procurement; targeted investment programmes for the defence industry or machine tool industry; and state procurement legislation, including selection of appropriate contract models.

Early post-Soviet development – lack of policy initiatives

During the general economic shock that followed upon the transition from a centralised and planned economic system to a market economy, in the 1990s, the machine tool industry fell into free fall. Demand for its products dwindled away, and without sufficient revenues the companies could not keep their qualified staff, nor successfully participate in the on-going digital reorientation of the global machine tool industry. In addition, privatisation often added to the crisis. Machine tool plants were usually privatised and taken over by their own former Soviet directors.

[126] Carlsson, *op. cit.*, pp. 17–19.
[127] Minpromtorg, *Strategiia razvitiia*, p. 12.

As the main shareholders, these directors usually assumed control of the main leading strategic positions within their companies, as well. This confusion of the supervising and executive roles typically created a weak corporate governance structure that further undermined what little competiveness the companies still retained.[128]

During this period, the Russian government remained indifferent to the crisis within the machine tool industry, as it was not a priority of the first generation of Russian reformers. For instance, according to former Soviet Minister of Machine Tools and Tool Industry Nikolai Panichev, in early 1992 then-acting Prime Minister Egor Gaidar allegedly told him that there was no further need for a domestic machine tool industry, as it was possible to buy more advanced machine tools from abroad.[129]

The first twenty post-Soviet years were, accordingly, lost decades for the domestic machine tool industry. To the extent it had an interest in domestically-produced machine tools at all, the Russian government merely relied on market forces to solve all issues. It likewise refrained from regulating the entry of foreign machine tool companies into the Russian market. As shown in Chapter 2 in this report, the machine-building industries' demand for machine tools increased, but Russian machine tool manufacturers lost about 90 per cent of their home market during this period. By 2009, about 40 companies – a fourth of the entire industry – had had to close down.[130]

The beginning of reforms

From 2007 onwards, the Russian government took a more active interest in machine tool building. In late December that year, the Ministry of Industry and Energy – a predecessor to the present Ministry of Industry and Trade – approved a plan of priority measures for the coming years, up to 2011.[131] However, the priority

[128] RNS Informatsionnoe agentsvo (2017): 'Sergei Nedoroslev o reanimatsii stankostroeniia', 19 June 2017, *https://rns.online/interviews/Sergei-Nedoroslev-o-reanimatsii-stankostroeniya--2017-06-19/*, [accessed August 21, 2018].

[129] Chebotarev, Aleksei (2017): 'Eks-ministr SSSR: bez stankostroeniia net importozameshcheniia', *Argumenty i Fakty*, № 27, 5 July, *www.aif.ru/money/market/sovetskiy_ministr_bez_stankostroeniya_ne_mozhet_byt_importozameshcheniya*, [accessed August 20, 2018].

[130] Bulanov, Aleksei (2017): 'Sobrat po chastiam: kak vozrozhdaiut stankostroenie v Rossii', Voennoe.rf Informatsionnoe Agentstvo, 3 March 2017, *https://xn--b1aga5aadd.xn--p1ai/2017/%D0%AD%D0%BA%D0%BE%D0%BD%D0%BE%D0%BC%D0%B8%D0%BA%D0%B01/*, [accessed August 21, 2018].

[131] Ministerstva promyshlennosti i energetiki RF: Prikaz ot 27 dekabria 2007 g. No 575 'Ob utverzhdenii Plana pervoocherednykh meropriiatii po razvitiiu stankoinstrumentalnoi promyshlennosti na period do 2011 goda' [Decree of the Ministry of Industry and Energy of the Russian Federation of December 27, 2007 No 575 'On approval of the Plan of priority measures for the development of the machine tool industry for the period until 2011'] , *www.garant.ru/products/ipo/prime/doc/6284532/*, [accessed August 23, 2018].

plan was but a standard list of support measures, such as: to stimulate investment and strengthen export, to encourage R&D and to develop the staff potential. Its main flaw was that it left the industry's structural problems unresolved; designed for a planned economy, the industry remained unsuitable for operation under market conditions.[132]

The most important provision of the plan was the establishment in 2008 of an independent State Engineering Centre under the auspices of Moscow State Technological University Stankin. The purpose of this centre is to facilitate the large-scale re-equipping of the entire Russian machine-building industry. Its strategic goal is to secure Russian long-term technological independence, along with the competitiveness of Russia's engineering industries, especially of its strategic high-tech companies and with regard to dual-use machine tools and instruments. Both the Ministry of Industry and Trade and the Ministry of Education and Science finance its activities.[133]

The 2011–2016 development programme and other policies

Starting in 2011, the Ministry of Industry and Trade initiated another round of policy initiatives. The most important was the adoption of a new development programme for the machine tool and tool industries for 2011–2016.[134] It was, formally speaking, a sub-programme of the much broader Federal Target Programme (FTP), 'The National Technological Base for 2007–2011'.[135]

The overarching goal of the programme was to replace the import of machine-building means of production related to dual-use technologies with domestic manufacturing. Dual-use machine tools are in great demand within Russia's strategic industries, not least within the defence industry. To accomplish the goal, the programme envisaged three tasks. The first was to develop and prepare serial manufacturing of dual-use machine-building means of production, focusing on advanced machine tools and instruments. The second was to organise both highly

[132] Kostrikin, Konstantin (2008): 'Stankoinstrumentalnyi ansambl', *Kommersant*, Prilozhenie No 44, 19 March 2008, *www.kommersant.ru/doc/866541*, [accessed August 23, 2018].

[133] Information retrieved from the webpages of MSTU Stankin, *http://ckp-stankin.ru/en/about* and *http://www.stankin.ru/gic/* www.stankoprom.ru, [both accessed August 21, 2018]. RBK Delovoe informatsionnoe prostranstvo (2007): 'Rabochaia gruppa Minpromenergo predlagaet obedinit stankostroitelnye predpriiatiia na baze OAO Rosstankoprom, 18 December, *www.rbc.ru/rbcfreenews/20071218185309.shtml*, [accessed August 23, 2018].

[134] Pravitelstvo RF (2011): 'Podprogramma "Razvitie otechestvennogo stankostroeniia i instrumentalnoi promyshlennosti" na 2011 - 2016 gody federalnoi tselevoi programmy "Natsionalnaia tekhnologicheskaia baza na 2007 - 2011 gody"' in accordance with 'Postanovlenie Pravitelstva RF ot 1 iiulia 2011 g. N 531 "O vnesenii izmenenii v postanovlenie Pravitelstva Rossiiskoi Federatsii ot 29 ianvaria 2007 g. N 54"', *http://dokipedia.ru/document/5165706?pid=148*, [accessed August 24, 2018].

[135] In Russian: Federalnaia tselevaia programma 'Natsionalnaia tekhnologicheskaia baza' na 2007–2011 gody.

efficient manufacturing sites and workshops to produce such machine tools and instruments and, at Russia's leading machine tool and instrument companies, specialised and tailor-made machine tools and instruments.

With the third task, it became obvious that the Ministry of Industry and Trade had plans to change the underlying organisational structure of the machine tool and tool industries. Based on an earlier proposition that had not yet been implemented in full under the preceding priority plan, the Ministry envisaged the creation of so-called system integrators (in some texts also described as 'national champions').[136] These were to specialise in technological audit and the re-equipping of machine-building firms, using predominantly domestic machining equipment and tools.[137]

To accomplish this task, the Ministry of Industry and Trade had already gathered all state assets in machine tool building in a comprehensive holding company back in 2009. Under the new programme, this structure was subsequently incorporated in the Rostec State Corporation[138] as JSC 'Stankoprom'. Basically, Stankoprom is a vertically integrated holding company that in 2018 consisted of thirteen entities specialising in R&D, machine tools and tool manufacturing, as well as trade and engineering. Its purpose is to function as a system integrator for the technical re-equipping of the defence industry. It is also an instrument for creating joint ventures with foreign machine tool companies and regaining control over machine tool import.[139]

The cost of the 2011–2016 programme amounted to 26 billion roubles, of which half was at the expense of the federal budget and the rest from 'extra-budgetary funding'. The programme does not clarify the meaning of extra-budgetary funding. However, according to the overarching FTP programme, 'The National Technological Base for 2007–2011', 'sources of extra-budgetary funds are the financial resources of the implementing organisations and borrowed funds (bank loans, borrowed funds from other organisations, funds from potential technology consumers)'.[140] It is likely that the development programme for machine tools is based on the same terminology. This interpretation is also reinforced by the fact that extra-

[136] RBK (2007): 'Rabochaia gruppa Minpromenergo predlagaet obedinit stankostroitelnye predpriiatiia na baze OAO 'Rosstankoprom', 18 December 2007, *https://www.rbc.ru/rbcfree-news/20071218185309.shtml*, [accessed August 21, 2018].

[137] Pravitelstvo RF 'Podprogramma "Razvitie otechestvennogo stankostroeniia"'.

[138] Rostec is a state-owned holding conglomerate founded in 2007 and specialising in consolidating strategically important companies, mainly in the defence and high-tech industries, and promoting development, production and export of high-technology industrial products for the military and civil sectors.

[139] Information retrieved from Stankoprom webpage, *www.stankoprom.ru*, [accessed August 21, 2018].

[140] Pravitelstvo Rossiiskoi Federatsii (2007): *Federalnaia tselevaia programma 'Natsionalnaia tekhnologicheskaia baza' na 2007–2011 gody* v red. Postanovlenii Pravitelstva RF ot 26.11.2007 N 809, ot 01.07.2011 N 531, ot 06.10.2011 N 820, *http://fcp.economy.gov.ru/cgi-bin/cis/fcp.cgi/Fcp/ViewFcp/View/2014/240/*, [accessed September 19, 2018].

budgetary funding is reserved for such measures that are phased in late in the development programme. They are thus closer to commercialisation, which is why it is reasonable to assume that those organisations that will directly benefit from their implementation would also take the main responsibility for their financing.

Of the federal budgetary means, 42 per cent were reserved for R&D financing 2011–2013, 36 per cent for the start-up of serial production in 2014–2016, and nineteen per cent for capital investments. The yearly allocation of capital investments was supposedly to increase until 2013, followed by a gradual phasing out by 2016.[141]

The envisaged outcome of the programme was outlined in three different categories of target indicators. The first category related to the specific amount of new types of machine-building tools and instruments put into serial production. The second category addressed the production capacity added for the manufacturing of these items. The third set regarded the targets for the anticipated increases in yearly production volumes, measured in roubles for 2014–2016, which the first two targets were supposed to bring about.[142]

The development programme coincided with the launching of the new State Armament Programme 2011–2020[143] and the accompanying Federal Target Programme for Development of the Defence Industry Complex up to 2020[144]. This was not a coincidence, as these two programmes were assumed to stimulate the demand side of the Russian machine tool market, further helping the domestic machine tool industry to recover.

A necessary precondition for this to happen, however, was to limit further purchases of foreign machine tool equipment. For that reason, the Government adopted decree number 56, in February 2011, which was further developed and supplemented by decree number 1224, in December 2013.[145] These two decrees forbade purchases of foreign equipment – including machine tools – regarding undertakings related to defence and national security, provided that Russian-made

[141] Pravitelstvo RF (2011): 'Prilozhenie no. 2 k Podprogramma "Razvitie otechestvennogo stankostroeniia i instrumentalnoi promyshlennosti" na 2011 - 2016 gody federalnoi tselevoi programmy "Natsionalnaia tekhnologicheskaia baza na 2007 - 2011 gody", chapter IV 'Obosnovanie resursnogo obespecheniia Programmy', *http://dokipedia.ru/document/5165706?pid=148*, [accessed August 24, 2018].

[142] Pravitelstvo RF (2011): 'Prilozhenie no. 1 k Podprogramma "Razvitie otechestvennogo stankostroeniia i instrumentalnoi promyshlennosti" na 2011 - 2016 gody federalnoi tselevoi programmy "Natsionalnaia tekhnologicheskaia baza na 2007 - 2011 gody", *http://dokipedia.ru/document/5165706?pid=148*, [accessed August 24, 2018].

[143] In Russian: 'Gosudarstvennaia programma vooruzheniia na 2011–2020 gody'.

[144] In Russian: Federalnaia tselevaia programma (FTsP) 'Razvitie oboronno-promyshlennogo kompleksa Rossiiskoi Federatsii na 2011–2020 gody'.

[145] *Postanovlenie pravitelstva* no. 56 ot 07.02.2011 and *Postanovlenie pravitelstva* no. 1224 ot 24.12.2013.

equivalents were available.[146] Together with certain other government decrees concerning the machine tool industry, these decrees were adopted in consensus with the Stankoinstrument Association – an interest group for the machine tool and tool industries.[147]

An updated version of the development programme was later incorporated in the 'State programme for the development of the industry and increase of its competitiveness'.[148] The state has also continued to support the machine tool industry through other financial and non-financial mechanisms.[149] For instance, Russia's import substitution plans include several measures to further curb the strategic companies' dependence on foreign technological means of production.[150]

So far, most of these policies have not produced the desired outcome. Admittedly, the partially state-financed R&D activities carried out in 2011–2013 resulted in 28 new inventions, but as late as 2017 they had not been commercialised.[151] It has also proven difficult to limit the inflow of foreign-made machine tools and instruments. In 2013, more than 300 import applications from the defence industry were rejected. Nevertheless, in most of these cases, the interested company then either abstained from making the planned capital investment, or found ways to circumvent the ban.[152]

Russian import restrictions on machine tools have nonetheless guided a number of foreign companies within the high-end segment to localise some of their production to Russia. The Russian government has not only welcomed but also hoped for this to happen, as it brings about at least a minimum of technology transfer. In Ekaterinburg, the Japanese company Okuma has created a joint venture together with the Russian firm Pumori, which also assembles machining centres from Indian Ace Manufacturing Systems in Perm. Takisawa, another Japanese firm, has launched assembly production in Kovrov and, in Azov, Czech KOVOSVIT MAS has created a joint venture together with the local Gruppa MTE. In Ulianovsk, the

[146] Telmanov, Denis (2012): 'Na rossiiskie stanki prikhoditsia ne bolee 10% sredstv sredstv, napravliaemykh na modernizatsiiu', *Izvestiia*, 4 April, *https://iz.ru/news/520900*, [accessed August 28, 2018].

[147] Kovalenko, Iurii (2011): 'Stankostroitelnaia otrasl zhdet ot pravitelstva programmy modernizatsii', PV.RF Mezhdunarodnyi promyshlennyi portal, 20 September, *https://promvest.info/ru/tehnologii-i-oborudovanie/stankostroitelnaya-otrasl-jdet-ot-pravitelstva-programmyi-modernizatsii/*, [accessed August 29, 2018].

[148] Pravitelstvo RF (2014): Gosudarstvennaia Programma RF 'Razvitie promyshlennosti i povyshenie ee konkurentosposobnosti', in accordance with 'Postanovleniem Pravitelstva RF ot 15 aprelia 2014 g. N 328'.

[149] Minpromtorg, *Strategiia razvitiia*, pp. 35–36.

[150] Minpromtorg (2015): 'Ob utverzhdenii plana meropriiatii po importozamezheniiu v stankoinstrumentalnoi promyshlennosti Rossiiskoi Federatsii', *Prikaz no. 650*, 31 March 2015, *http://ulsubcontract.ru/wp-content/uploads/2015/05/650.pdf*, [accessed September 19, 2018]; See also Minpromtorg, *Strategiia razvitiia*, p. 35.

[151] Minpromtorg, *Strategiia razvitiia*, p. 34.

[152] Mekhanik, 'Bez svoikh cherviakov ne oboidemsia'.

German-Japanese company DMG MORI has obtained the status of local producer, since it has localised production and technology development and to a large extent uses locally manufactured subcomponents.[153]

The proposed development strategy to 2030

In June 2017, the Ministry of Industry and Trade, under Minister Denis Manturov, proposed a new comprehensive development strategy for the machine tool and tool industries 2018–2030.[154] Compared to the 2011–2016 programme, the Ministry built this strategy on a deeper analysis of the Russian machine tool market structure and its role in Russia's socio-economic development. Notably, it also drew more on international comparisons and experiences and current global trends in machine tool-building and industry organisation than did previous documents. In these parts, the proposed strategy is much more modern than its predecessor.

The primary goal of the proposed strategy is to increase the competitiveness of the Russian machine tool and tool industries and to restore their position on the home market. By 2030, the share of Russian machine tools on the domestic market should increase to 50 per cent and the yearly growth rate should be 15 per cent, on average, according to the proposed target indicators.[155]

According to the Ministry proposal, the strategy should be implemented in two stages. During the first stage, up to 2021, all state policies for the machine tool industry ought to focus on strengthening the position of a few strong market actors among current companies and turn them into national champions. The state should also stimulate the emergence of new market participants in those market niches where the current companies are not active. The purpose of state policy during this stage is thus to bring about intensive economic growth within the industry, to empower existing companies to fully exploit their potential, to develop new technologies and to seize broad market niches.

During the second stage, 2022–2030, the industry should be capable of shifting towards extensive growth. Production volumes would increase as a result of the active state support during the previous stage. The Ministry expects new actors to enter those market segments for final products, subcomponents and instruments that the national champions have not already seized. Among them will be technology owners, modernised defence firms and companies from the nuclear industry. By then, the plan is for the industry to have developed competitive technological alternatives within those market segments that depend on import. The Ministry forecasts that some of the new technology needed for this should be generated from joint ventures between Russian and foreign companies.

[153] Bulanov, *op. cit.*
[154] Minpromtorg, Strategiia razvitiia
[155] Minpromtorg, *Strategiia razvitiia*, p. 55.

Total expenditure 2018–2030 for the strategy for investments in R&D and production capacity amounts to 65.3 billion roubles, according to the Ministry's calculations. The Industry Development Fund[156] would cover almost half of the expenditure and the federal budget another thirty per cent. The industrial actors would have to finance twelve per cent and the remaining ten per cent needs to be borrowed.

The proposed strategy is heavily front-loaded; most expenditures are allocated up to 2023. In addition to the expenditures needed to implement the strategy, another 5.9 billion roubles in subsidies is needed for liquidity support to the industry as well as 10.8 billion roubles to finance commercialisation of R&D activities.[157]

As late as autumn 2018, there was no public information on whether the strategy had been adopted. Still, the draft strategy provides clues about how the Government assesses the efficiency and effectiveness, or rather the lack thereof, of previous policies. For instance, it is telling that the financing volume has increased 2.5 times compared with the 2011–2016 programme and that the state-financed share remains the largest. It is obvious that previous policies have not produced the desired results. In spite of this substantial increase in allocated resources, in its present form the strategy fails to address some central issues, as it only addresses questions of a technological or organisational character. It avoids the underlying economic and financial root causes that put the industry in its current uncompetitive position from the beginning. Two examples have already been mentioned in Chapter 4.3 of this study: the lack of access to competitive short-term liquidity loans, and the rigid budgetary framework of the state procurement system, which discourages the entire machine-building industry – especially the defence industry – from investing in Russian-made machine tools. In this case, the strategy's approach to ameliorating the situation is merely to provide for more subsidies and state-backed liquidity loans.

Altogether, the strategy represents a step backwards, towards a traditional Russian development model characterised by a high degree of state control and a deep mistrust of the free market. The state is deeply involved in all processes, from setting up an appropriate market structure and determining the orientation of R&D activities, to promoting commercialisation of new technologies and products. Due to this micro-management, and the sheer number of proposed activities that have to fit into each other in a holistic pattern of function and time, the proposed strategy is rather complex. This, of course, increases the risk that some critical issues might have been overlooked or that certain delays might cause the strategy to fall apart.

[156] In Russian: *Fond razvitiia promyshlennosti*, *http://frprf.ru/*.
[157] Minpromtorg, *Strategiia razvitiia*, p. 81.

5.3 Summing up

Is Russia's government support to its machine tool industry justified? Considering the industry's strategic significance, its dire condition and obvious inability to overcome the persistent crisis on its own, the answer is undoubtedly yes. Russia's present foreign policy course, which has put it at risk of Western sanctions and its dependence on foreign-made machine tools – dual-use machine tools included – threatens its room for political manoeuvre on the global scene and, in the end, its national security.

The answer is equally yes in the domestic political context. Public spending on arms, aircraft development, the space industry and the energy infrastructure remains a major driver of machine tool demand within the Russian economy. As domestic manufacturers succumb, a continuous indirect outflow of Russian budgetary means to foreign machine tool providers is unacceptable to industry lobbyists and employees alike. Possibly, it is unacceptable to Russian tax payers as well, at least in the long run.

The question remains whether Russian state interventions towards the machine tool industry are justified in terms of effectiveness and efficiency. In this case the answer is no. Specified policy goals have been only partially achieved or not achieved at all. Nor has the branch been able to exploit the momentum of greater demand for machine tools, and, in later years, a weak rouble, to build competiveness and increase its market share.

State support up to the late 2010s has so far consisted of subsidies for R&D, technological re-equipping of Russian machine-building enterprises and increases of production capacity. Another direction has been to replace import with domestic production via legislative changes. None of these policies has solved the industry's structural problems; they have not contributed to a balanced and competitive market, nor have they been capable of providing Russian machine tool manufacturers with industry profitability.

The envisaged policy direction for the machine tool industry seems to provide more of the same, albeit with even stronger state management of the sector. While Russian authorities do not discourage new domestic actors from emerging, they have concentrated their efforts towards the strongest remaining inheritors of the Soviet machine tool industrial complex. The current direction does not draw a line under soft budget constraints and rent-seeking behaviour. It gives the impression that lobbying efforts from the well-established companies have had a strong impact on policy development, which is not an optimal outcome for the industry as such, nor for Russia's traditional machine tool buyers.

6 Conclusions: prospects for an industrial turnaround?

Since it hit bottom in 2009, Russia's machine tool production has not only levelled out, but the quantity of metal-cutting machine tools has doubled. Such an increase would hardly have been possible if it had not set off from a very low level, where domestic production oscillated between ten and fifteen per cent of total demand. In fact, domestic production is still effectively uncorrelated with demand among Russia's major machine-building industries – all of them considered strategically important to the Russian economy, further technological development and national security.

Despite, or perhaps because of the anaemic existence of Russia's machine tool manufacturers, the financing for the draft strategy plan for Russia's machine tool industry until 2030 suggests that the Russian government is determined to revive this industry and turn it into a major provider of machine tools for the Russian market.

6.1 Substantial state interest

Why is the domestic machine tool industry important to the Russian government? The military-strategic argument is by far the strongest one. During the Soviet period, it was the domestic machine tool industry that underpinned industrialisation and armament and helped transform the Soviet Union from an agrarian country into a superpower on almost equal terms with the USA. Without a sufficiently advanced machine tool industry, if the Soviet Union had been more dependent on machine tool import during this period, this transformation would hardly have been possible. When the Cold War ended, the importance of an independent and advanced machine tool industry at first no longer seemed relevant to the Russian political leadership. Once Russia's political development started to gravitate away from the relaxed post-Cold War consensus of the early 1990s, the situation changed. Russia's present foreign policy course puts it at odds with Western powers. As long as it depends on foreign-made machine tools to produce arms and other sensitive and technologically advanced machinery, Russia's talk of national sovereignty will remain hollow. It will continue to be vulnerable to sanctions and interruptions of deliveries.

The current Russian government also formulates its policy in economic-strategic terms. Its starting point on industrial matters is that Russian industry is a complicated network of interrelated and interdependent industrial businesses and industries, a set of communicating arteries linked together in an intricate pattern. The scars left behind by the wave of Schumpeterian creative destruction that swept over the Russian economy during the 1990s still frighten Russian policymakers. For that reason, the government prefers a state-managed comprehensive approach

to industrial matters, in lieu of the seemingly whimsical arbitrariness of a spontaneous and decentralised free market over which the state has lost most control and exercises only a minimum of power. The government's strategy is therefore to compile and implement a complex and multidimensional plan for the modernisation of the entire Russian manufacturing industry, a plan that is and will have been brokered with the main industries and their major actors in appropriate joint public-civil committees.

The Russian government also firmly places its policy for the machine tool industry within the framework of its wider technological strategy. Being one of Russia's core strategic industries, the success of the domestic machine tool industry is crucial to the government's long-term strategy to turn Russia's oil- and gas-dependent economy into a competitive manufacturing economy of high-technology products for a global market. Given the machine tool industry's key position within the manufacturing system, it is crucial not only for production within all other industries, but also for the pursuit and inter-industrial transfer of new technologies and production techniques. The machine tool industry is therefore more or less a necessary precondition for any other parts of the strategy to materialise. One might indeed question the realism of the government's comprehensive industrial strategy, but it nevertheless demonstrates the government's ambitions and forms the basis for Russia's current industrial policies.

In the same way as the historically high oil price during the mid-2010s boosted the State Armament Programme 2011-2020, it paved the way for a series of more ambitious and better financed government support programmes for different industries. Among these were the development programme for the machine tool industry 2011–2016. Although the external economic conditions had deteriorated by 2018, this momentum is still visible. In addition, Russia's relations with a number of countries have worsened rapidly since 2014, exposing it to sanctions, and making import substitution of foreign-made high-end products, including machine tools, a top industrial policy priority. The Wassenaar Arrangement will continue to fuel insecurity in Russia. In the agreement's capacity as an information-sharing and standard-setting forum on export controls for conventional arms and dual-use goods and technologies, one state's reluctance to export a certain type of a dual-use machine tool to Russia might spread to other countries as well.

6.2 The research question revisited

Given this massive interest from the state, are there any realistic prospects for a sustainable turnaround of the Russian machine tool industry? Or, to revisit the research question, would it be possible for the Russian machine tool industry to significantly increase its share of its home market and once again become the major supplier of advanced machine tools to Russia's strategic industries by 2030?

For a complete answer to this question, it would have been appropriate to add the conduct and performance of Russian machine tool companies to the analysis. Company conduct, or strategic behaviour, affects industry and firm performance in terms of, for instance, efficiency, profitability, productivity, technical progress, growth and product quality. Conduct and performance are therefore crucial variables in industry and company competitiveness.

An analysis, however, of Russia's machine tool industry structure, present state policies and support provides a good indication of the possibilities for a revival of the Russian machine tool industry.

Significant structural difficulties

The dynamic changes that have taken place in the Russian machine tool market after the Soviet collapse demonstrate the initial lack of competitiveness of Russia's domestic machine tool industry. The industry structure and the market forces of 2018 still worked against Russia's remaining, mostly Soviet-inherited, machine tool companies. As it appeared then, Russian machine tool firms had as yet no prospects for long-term profitability. Left on its own, the industry has struggled, mostly in vain, to profit from the surge in machine tool demand that followed from Russia's industrial investments during the last decade, particularly in the defence industry, in order to support military rearmament. Nor has it been able to exploit the weak rouble of later years to significantly increase its share in the domestic market or enlarge its export.

As regards the defence industry's demand for capital goods, it was to a large extent saturated with foreign-made machine tools during the support programme that accompanied the State Armament Programme 2011–2020. The Armament Programme for 2018–2027 is more intended to consolidate the progress in equipment recapitalisation already achieved during the once-and-for-all catching up exercise of its predecessor. It thus signals a transition to a more regular procurement schedule. The primary task for the defence industry in this regard during the 2020s is therefore to preserve its rebuilt production capacity rather than increase it further. All depends on whether increases in arms export and civilian transfers will compensate for a loss of military production to keep capacity operational.

For these reasons, the defence industry's demand for machine tools during the 2020s is expected to shrink. The domestic defence market segment for machine tools might therefore become an arena for more intense competition in the nearest future.

These uncertainties within the defence industry might be an additional factor to those discussed in Section 4.3 above, regarding the issue of why private investment in the machine tool industry is low – a feared lack of demand from the defence industry.

As if these circumstances were not discouraging enough, Russian machine tool manufacturers also have to overcome the path dependence that has evolved within the defence industry due to its preference for foreign-made machine tools. Experience shows that major complications are often associated with integrating Russian-made machine tools into a machine park that to a large extent already consists of foreign-made machine tools, and which might be based on other nomenclatures, technical standards and production solutions.

All told, the Russian machine tool industry appears to have taken few initiatives on its own to cope with the new competitive environment that emerged after 1991. The industry remains financially weak, company management is feeble, and revenues are too small to allow for company R&D that is future-oriented. In addition, there is a lack of blue- as well as white-collar workers, which, in turn, holds back technological progress even further.[158]

The most important exception to this dismal characterisation is the Stan Holding Company, which was formed in 2012. According to its own company information, in 2018 its seven subsidiaries produced more than half of all metal-working machine tools manufactured in Russia. It is possible that Stan Holding might become one of those industrial leaders or national champions that the state believes are necessary to steer the entire industry into the future. On the other hand, if it remains without serious competitors, Stan Holding might just turn into a complacent monopoly living off soft budget constraints, causing market inefficiencies and deadweight losses for everyone involved.

State involvement

The Russian government provides direct support to the domestic machine tool industry through targeted industrial development programmes as well as through separate policies. Throughout the 2010s this support corresponded more or less to a standardised list of industrial policy actions that included everything from investments in R&D; commercialisation of prototypes and serial production; to work training, education, manpower and staffing issues.

The government has also tried to support the machine tool industry indirectly by stimulating industrial investments in new machinery and manufacturing equipment among Russia's other metal working and machine-building industries. This is especially the case regarding the defence industry. An anticipated side effect of the State Armament Programme 2011–2020 was that it would increase demand among Russia's defence companies for new Russian-made machine tools. The state even set up a targeted investment programme directed at the defence industry for this purpose.

[158] Minpromtorg, *Strategiia razvitiia*, pp. 26–28.

The state has accordingly taken responsibility for generating supply as well as demand for Russian-made machine tools on the Russian market, effectively blocking most market solutions and putting a dead hand over a market-oriented business development. In the late 2010s, Russian machine tool builders had therefore yet to develop direct relations with the end-users of machine tools and to grow a more profound service-mindedness towards them. As things stand, the Ministry of Industry and Trade too often acts as a proxy customer, obfuscating direct business-to-business relations. The market structure of the 2010s therefore seemed to be well on its way to degenerating into a Soviet management model.

It is then all the more noteworthy that in spite of its heavy-handedness, the Russian government has failed to protect the domestic machine tool market from foreign machine tool providers or their agents. The defence industry's demand for new machine tools certainly did increase under the State Armament Programme 2011–2020, but in most cases the defence companies chose to use their revenues and state subsidies to procure foreign-made machine tools. The government's efforts to ban foreign-made machine tools in military-related production have turned out to be futile. Most defence companies have either chosen to deliberately circumvent the import ban or to abstain from their planned capital investments. In addition, Russia's membership in the World Trade Organisation, WTO, has undermined the competitiveness of Russian machine tool builders further, as Russia has had to lower its import tariffs on machine tools and their subcomponents. The weakening of the rouble after the mid-2010s has so far barely neutralised this impact.

6.3 Future challenges

The government's underperforming policies and the industry's persistent inability to break its vicious circles of non-competitiveness and poor profitability imply that their efforts have either been misallocated, insufficient, or both. The current policies are nevertheless a matter of choice, for which other alternatives have so far not been exhausted. For instance, the government could choose to put its own representatives on the board of directors of state-owned machine-building companies. It would then be able to steer capital investments within these companies towards Russian instead of foreign machine tools, thus significantly increasing its leverage as a market regulator without greater costs for the state. Such an approach would preserve a larger element of market mechanisms than the current blunt prohibition against foreign-made machine tools for defence-related production, which the companies try to circumvent in any case.

The government has furthermore avoided addressing the Russian financial and economic structure that distorts competition to the disadvantage of Russian manufacturing industries, including the machine tool industry. Russia has tighter credit conditions, larger collaterals and higher interest rates than most of its trading partners, which hamper business development. To remedy the situation, the government has confined itself to targeted state subsidies and loan guarantees for selected

companies and industries. Instead of promoting a general improvement of the entire financial infrastructure, the Russian government has in this way contented itself with paving the way for an economic patron-client-system that it can control, which has just distorted the market mechanisms further.

On their part, Russian machine tool manufacturers have shown little adaptability to global trends within their industry. One of the most important is an increased element of vertical disintegration of production, in this case a more layered production with tiered supply chains and an original equipment manufacturer, OEM, at the top. In contrast, Russian machine tool companies still produce a large share of their components and subcomponents in-house. To the extent that they purchase components from others, they mostly rely on foreign suppliers.

Russian machine tool manufacturers are aware of the on-going universal convergence of industrial production with information and communication technologies taking place in other countries. So far however, they have not drawn any far-reaching conclusions regarding its impact on their own industry. The system-integrating ambitions of the above-mentioned JSC Stankoprom might be a possible exception, but taken together, Russian machine tool builders first and foremost produce machine tools, and they base their competiveness on the technical performance of their products. This means that they have so far overlooked the on-going paradigm shift, where especially high-end machine tool companies are transforming from being merely manufacturers to becoming 'process solution partners' that are more or less integrated into their customer's entire business and manufacturing processes. Again, to succeed, such a business concept requires direct business-to-business relations between the machine tool manufacturer and presumptive customers to succeed, which is one of the weak points of the Russian machine tool industry.

Prospects for 2030

In spite of the then industrial stabilisation and the government's effort to make the domestic machine tool industry more competitive, in 2018 there were no signs that a sustainable turn-around was imminent. As suggested in the proposed development strategy regarding the 2018–2030 period, a market share of 50 per cent of the domestic market in 2030, based on a yearly growth rate of 15 per cent during the 2020s, therefore appeared unrealistic. This was the case not least in view of the modest import substitution goals for 2020 that the Ministry of Industry and Trade has set up for the machine tool industry. Another factor that will probably slow down the transition is the prevalent path dependence on foreign-made machine tools.

Based on the findings in this study, it therefore seems highly likely that production within Russia's strategic industries – particularly within the defence industry – will rely, by and large, on foreign machine tools well into the 2030s. Russia's relations with different providing countries will therefore to some extent be decisive for

what Russia is able to produce: high-quality machinery for monopolistic markets, or non-expensive and good-enough products for mass production markets based on price competition? The answer to that question is not trivial for the future composition of the Russian economy and its place within the world manufacturing system towards 2030.

At the end of the day, the answer to the question also entails important geostrategic implications. Is Russia prepared to cultivate sufficiently good relations with the West to get what it needs in high-end machine tools, or will it make do with what it can find from wherever it can get it? Either of those choices might in their own way deny Russia from meeting its long-term geostrategic goals.

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Appendix

Table A:1: Statistical classification of machine tools according to products by activity

Code	Title
28.4	**Metal forming machinery and machine tools**
28.41	**Metal forming machinery**
28.41.1	*Machine tools for working metal, operated by laser and the like; machining centres for working metal and the like+*
28.41.11	Machine tools for working metal by removal of material by laser, ultra-sonic and the like
28.41.12	Machining centres, unit construction machines and multi-station transfer machines, for working metal
28.41.2	*Lathes, boring and milling machine tools for working metal*
28.41.21	Lathes for removing metal
28.41.22	Machine tools for drilling, boring or milling metal; machine tools for threading or tapping metal not elsewhere classified
28.41.23	Machine tools for deburring, sharpening, grinding or otherwise finishing metal
28.41.24	Machine tools for planing, sawing, cutting-off or otherwise cutting metal
28.41.3	*Other machine tools for working metal*
28.41.31	Machines for bending, folding and straightening metal
28.41.32	Machines for shearing, punching and notching metal
28.41.33	Forging or die-stamping machines and hammers; hydraulic presses and presses for working metal not elsewhere classified
28.41.34	Machine tools not elsewhere classified for working metal, sintered metal carbides or cermets, without removing material

Source: Eurostat, *http://ec.europa.eu/eurostat/web/cpa-2008*

Table A:2: Statistical classification of machine tools according to the Harmonised system

Code	Title
8456	Machine-tools for working any material by removal of material, by laser or other light or photon beam, ultrasonic, electro-discharge, electro-chemical, electron beam, ionic-beam or plasma arc processes (excl. cleaning apparatus operated by ultrasonic processes, soldering and welding machines, incl. those which can be used for cutting, and material testing machines)
8457	Machining centres, unit construction machines "single station" and multi-station transfer machines for working metal
8458	Lathes, incl. turning centres, for removing metal
8459	Machine-tools, incl. way-type unit head machines, for drilling, boring, milling, threading or tapping (excl. lathes and turning centres of heading 8458, gear cutting machines of heading 8461 and hand-operated machines)
8460	Machine-tools for deburring, sharpening, grinding, honing, lapping, polishing or otherwise finishing metal, metal carbides or cermets by means of grinding stones, abrasives or polishing products (excl. gear cutting, gear grinding or gear finishing machines of heading 8461 and machines for working in the hand)
8461	Machine-tools for planing, shaping, slotting, broaching, gear cutting, gear grinding or gear finishing, sawing, cutting-off and other machine-tools working by removing metal, sintered metal carbides or cermets, not elsewhere classified
8462	Machine-tools, incl. presses, for working metal by forging, hammering or die-stamping; machine-tools, incl. presses, for working metal by bending, folding, straightening, flattening, shearing, punching or notching; presses for working metal or metal carbides, not specified above
8463	Machine-tools for working metal, sintered metal carbides or cermets, without removing material (excl. forging, bending, folding, straightening and flattening presses, shearing machines, punching or notching machines, presses and machines for working in the hand)

Source: International Trade Centre, *www.intracen.org/itc/market-info-tools/statistics-export-product-country/*

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