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The machine tool industry of Russia at a time of war and sanctions

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ABSTRACT

The article is devoted to an analysis of the development of the Russian machine tool industry before and after Russia's invasion of Ukraine in February 2022. It reviews the history of the industry in the USSR, its collapse in the 1990s and stabilisation in the early 2000s. Prior to Russia's annexation of Crimea in 2014 and the imposition of sanctions by Western countries the government had already adopted policies to secure a revival of the industry on a more independent basis and some success was achieved. After 2014 the government's efforts to restore the industry intensified and the scale of output of metal cutting machine tools steadily increased. However, there was still a significant dependence on imports, especially of the most advanced types of equipment. After the start of the war in 2022 sanctions were rapidly intensified and more countries participated. Quite rapidly, imports from Western countries were replaced by imports from China and other non-sanctioning countries. The development of the domestic industry received new priority and output increased. By the end of 2023 the situation had to some extent stabilised. Notwithstanding sanctions, the Russian defence industry has been able to acquire the machine tools it needs, although not always of the highest quality.

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Introduction

On 24 February 2022, Russia launched a so-called 'special military operation' against Ukraine and this has now continued for over two years. In response, the USA, European Union and other allied countries imposed increasingly severe sanctions in an attempt to constrain the development of the Russian economy and limit the ability of its industry to produce weapons by restricting access to imported high technology and dual use goods, production equipment, components, and materials. It soon became evident that Russia's invasion of Ukraine had not gone according to original expectations of a rapid operation. Instead, a protracted conflict developed with heavy losses in both human and materiel terms. The Russian armed forces lost a significant quantity of armaments, in particular

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tanks and armoured vehicles, artillery and air defence systems, fixed-wing aircraft and helicopters. By the autumn of 2022 the Russian government faced the challenge of increasing sharply the production of weapons and munitions vital to the successful completion of the operation.

This article explores Russia's ability to meet this challenge at a time when its defence industry is experiencing sanctions and a range of economic constraints, not least a shortage of labour exacerbated by a partial mobilisation of personnel to serve in the armed forces. For the manufacture of modern weapons appropriate production equipment is essential. The sanctions imposed in 2014 after Russia's annexation of Crimea were intended to limit Russia's ability to import advanced machine tools such as multi-axes machining centres, very high quality grinding machines and control systems for advanced machine tools. In 2022, these sanctions were intensified to a significant extent. Is Russia still able to obtain advanced machine tools for use in the defence industry from domestic sources or imports? This has been questioned by some analysts in the West. An April 2023 report of the Center for Security and International Studies, Washington D.C., was extremely doubtful. Ultimately, Russia faces a critical deficiency of complex multi-coordinate precision machine tools of the most advanced categories, and it lacks the time and capability needed to find substitutes for Western suppliers. While Russian producers claim to have designed and built a high-end computer numerical control (CNC) machine tool entirely out of domestically produced components, assertions like this are difficult to trust or verify (Bergmann et al., 2023). The reasons why the CSIS authors reached this conclusion will be examined later, but first it is necessary to consider the Russian background.

This article focuses on the principal class of machine tools, those for cutting metal, and does not consider metal forming machines that change the shape of metal by the exertion of pressure such as forges and presses, or the new method of creating metal components, additive technology with the use of 3D printers. For those not familiar with the technology the appendix provides a brief guide. Thus the article is concerned with one important sector of the machine-building industry, and in the absence of more wide-ranging research the conclusions drawn apply to that sector only. A feature of the article is the range of sources consulted. Over the years there has been discussion of machine tool industry developments in the mass media, but this has often been poorly informed and at times, recently, propagandistic in character. This was also the situation in Soviet times and then it was found essential to explore in detail specialised industrial and technical sources, as in the author's publications of earlier years.¹ These publications are written by experts concerned directly with practical issues and were, and still are, largely free of inflated claims and not afraid of discussing problems and policy measures for their resolution.

The article first provides a brief summary of the development of the earlier Soviet machine tool and what happened to it in Russia in the 1990s. It then considers significant developments in the 2000s prior to Russia's annexation of Crimea, followed by an review of the evolution of policy from 2014 to the start of the new war in 2022. It then analyses in detail the development of the industry over that period. This is followed by an investigation of the impact of the war and the imposition of sanctions on the machine tool industry: has Russia's ability to produce metal cutting machine tools, in particular advanced machines, been seriously limited? In order to draw firm conclusions detailed quantitative evidence is assembled for the domestic production and imports for the year

2013, i.e. before the start of the first military intervention in Ukraine, to the end of 2023, followed by conclusions.

The Soviet and Russian machine tool industries

The USSR possessed the world's third largest machine tool industry in terms of the annual output of metal cutting machines and was the world's second largest consumer of them.

It had an output of 160,000 units in 1990, including 22,500 with numerical control (NC). Of these totals, the Russian Federation built about 742,000 and 16,700 (Goskomstat Rossii, 1994; Goskomstat SSSR, 1991). The defence industry produced machine tools, mainly for its own needs, to a large extent because the civilian Ministry of Machine Tool and Tooling Industry was not always able to meet its quality standards or build the special-purpose machines it needed to produce some types of weapons. Thus in the 1980s enterprises of the USSR defence industry produced annually more than 25,000 metal cutting machine tools, about 70% being special machines, machines of high and especially high precision, NC machine tools and machining centres (Serov, 2016). In 1990, the Russian defence industry built just over one-fifth of all metal cutting machine tools 15,276 out of 74,171 units (Total Output, 1998).

The defence sector also faced problems in importing advanced machine tools as access to them was restricted by the Western multilateral Cocom technology control regime, although the limits were not always strictly imposed and the USSR quite often found ways of bypassing them. Nevertheless, there is evidence that the denial of advanced production equipment had an impact as at the end of the Soviet Union the share of imported equipment in the defence industry was 17.9% of the total stock, compared with 27.2% in the rest of the machine-building industry (Voprosy ekonomiki i konversii, 1991).

In the 1990s and early 2000s output collapsed and many Soviet-era factories closed. There were occasional policy decisions to revive the industry, notably around 2007 when Sergei Ivanov was first vice premier, his six years before then as defence minister having served to make him aware of their importance for national security, but the engineering industry, including the defence sector, had become habituated to importing the machine tools it needed and distrusted the quality of the few domestic products still being built. In the 2010s, there was a modest recovery and in 2013 2,945 metal cutting machine tools were built, including 10 machining centres and 227 NC lathes.² This revival was then boosted to a quite significant extent by the sanctions imposed in 2014.

Why have assessments of Russia's machine tool industry been so negative?

The background outlined above goes a long way in explaining why assessments in the West have been so negative. The author is aware of only one in-depth examination in recent years of the state of Russia's machine tool industry and this has undoubtedly played a role in forming the now dominant view. The study by Tomas Malmlöf of the Swedish Defence Research Agency (FOI) provided an excellent overview of the development of the industry in Russia from Soviet times against the background of the general trends of development of the machine tool industry in the wider world (Malmlöf, 2019). However, it also had some significant limitations, above all its failure to register some of the significant developments discussed in the next section, including the emergence of

important new actors and the role of the defence industry. This weakness may relate to the fact that Malmlöf did not explore the specialist Russian publications on the machine tool and tooling industry and machine building more generally, in particular journals such as *Stanki i instrument*, *Ekspert.Metalloobrabotka*, *Ritm mashinostroeniya* and *Komplekt: ITO (instrument, oborudovanie, tekhnologiya)*. The informative website of the industrial association 'Stankoinstrument' was apparently consulted to only a very limited extent and the same applied to an important statistical source, the Unified Interdepartmental Information-Statistical System, EMISS. The above-mentioned CSIS report drew upon the FOI report and some other recent publications in a similar spirit, not on the whole well-informed of developments during the past decade.

Some significant developments prior to 2014

Before 2013 some new producers had begun to emerge, including a German-Japanese company, Ul'yanovsk machine tool-building factory, operating under the brand name 'DMG MORI', one of the most modern machine tool builders in Russia specialising in numerically controlled (NC) lathes and milling machines, and a number of defence companies started to build advanced machine tools for their own use. One of the most important domestic newcomers was 'STAN', a private company founded in 2012 bringing together some of the best producers of advanced machine tools, an initiative of an entrepreneur who had played an active role in the defence industry in the 1990s, Sergei Nedoroslev. The enterprises it took over included the Sterlitamak NPO 'Stankostroenie' in Bashkortostan, Ryazan stankostroitel'nyi zavod, Kolomna 'Stankotekh', 'Shlifoval'nye stanki', Moscow, a leading builder of grinding machines, and 'Ivanovskii stankostroitel'nyi zavod' located at the site of one of the most advanced producers of heavy machine tools of the USSR (Stan Company, 2016). Given his background it was not surprising that Nedoroslev considered meeting the needs of the defence industry for advanced machine tools his first priority and he thought that this could best be done by designing the machines in Russia, in consultation with customers, then building them with the use of imported components if necessary but striving to localise production as rapidly as possible. However, he soon ran into a problem. There was a long lead time to designing and building new machines and this made heavy demands on working capital. By 2016, the company was being kept afloat with the aid of credits and guarantees worth 3 billion roubles from Novikombank, the investment bank of 'Rostekh', preparing the ground for what was to happen later (Financier, 2016).

In 2013, the vast 'Rostekh' state corporation headed by Sergei Chemezov established 'Stankoprom' to act as a 'systems integrator' but the facilities within it were mainly research organisation and tooling factories, with only one serious long-established, very capable, machine tool builder, the Savelyovsk machine-building works, in Soviet times in the aviation industry (Stanki Katalog, 2022). By its aims and functions 'Stankoprom' supplemented the State Engineering Centre established in 2008 at the Moscow State Technological University 'Stankin' (GITs MGTU 'Stankin'), the principal centre for the education and training of machine tool specialists and a major research hub. The Engineering Centre was established to assist in the technological renewal of the engineering industry, in particular its high technology branches (Stankin, 2018).

Following the creation of 'Stankoprom', in July 2013 the development of machine tool building in the interests of modernising the defence industry was

discussed at a meeting chaired by Dmitrii Medvedev, prime minister, and held at 'Stankin's' GITs. Present were leading figures of industry, the Military-Industrial Commission, 'Rostekh', the director of 'Stankoprom', Sergei Makarov, the leaders of some of the main structures of the defence industry, the united aviation, shipbuilding, and aero-engine corporations and the tank-building 'Uralvagonzavod', and the president of the industry association 'Stankoinstrument', Georgi Samodurov. Medvedev noted that the consumption of machine tools was increasing rapidly but that 'on the whole the situation in machine tool building is far from being brilliant' (Medvedev & Manturov, 2013). A briefing paper accompanying the report of the meeting on the government website underlined this reality. In 2012 by the volume of metal working equipment produced Russia was 22nd in the world and the industry's share of GDP was 0.03%. Imports of machine tools accounted for 93.2% of the market, with Germany, China, Italy, and the USA being the largest suppliers.

Total investment in the machine tool and tooling industry during 2006–12 was only 2.7 billion roubles, with a mere \$4.7 million foreign investment. There was hardly any innovation and the industry's products could not be considered high-technology. Finally, the measures that had been taken did not meet the needs of the defence industry and its federal programme 'The development of the defence-industrial complex, 2011–20', which provided for 600–800 billion roubles worth of new machine tools, including more than 100 billion per year in 2015–17 (Government of the Russian Federation, 2013). Medvedev was confident that Russia had the machine tool expertise required to meet the challenge and measures had to be taken to promote domestic production to meet the needs of the defence industry, a priority he emphasised because at any time access to imported machines could be blocked; exactly what happened a few months later (Medvedev & Manturov, 2013).

In his introduction to the meeting Medvedev made reference to a decree of 2011 that had imposed some restrictions on the import of machine tools for the needs of the defence sector. This was the government decree of 7 February 2011, No.56, which said that machines listed in its appendix could be imported only if they were not produced in Russia or those produced did not meet the requirements of the customer. But the appendix was extremely general, simply listing almost all the basic types of machine tool (Government of the Russian Federation, 2011). As industry minister, Denis Manturov, observed after the meeting, the decree, meant to stimulate the development of the domestic machine tool industry, had limited impact because few of the types listed were actually manufactured in Russia. The decree would be amended to make it more effective and this task was included in the official orders (*porucheniya*) issued after the meeting, with an October 2013 deadline (Medvedev & Manturov, 2013). Manturov said that practical steps would be taken including the creation of joint enterprises and the development of capacities to build new machines, either through the Engineering Centre of 'Stankin' or through the systems integrator that had recently been created in Rostekh, i.e. 'Stankoprom'. Thus prior to the spring and summer of 2014, a start had been made in laying the foundations of a domestic machine tool industry with a better capacity to meet the needs of the defence industry.

The evolution of policy from the imposition of sanctions in 2014

From March 2014 the United States and the European Union began to apply sanctions against Russia and were followed by other countries, including Japan, and by July they included measures to restrict access to high technology and dual use goods that could be applied in military production. The Commerce Control List of the US Bureau of Industry and Security which informed the sanctions included advanced machine tool such as multi-axes machining centres with turning, milling or grinding capabilities, precision grinders, advanced machines for removing metal by laser, electrical discharge or electron beam, and certain types of NC machines. The list also included a range of numerical control systems and software for them (Bureau of Industry and Security, 2023). These sanctions were applied by most of the countries supplying advanced machine tools to Russia, including the USA, Germany, Italy, France, UK, Czech Republic, Japan, and Switzerland, but not South Korea and Taiwan (Connolly, 2018).

One of the first measures to promote the development of the Russian machine tool industry just predated the imposition of the restriction on access to dual use technologies. There was a government decree of 15 April 2014 approving a new state programme, 'The development of industry and raising its competitiveness', which incorporated as a sub-programme 'Machine tool and tooling industry' the one that had previously been part of the 'National technological base' programme. One of its specific tasks was import substitution of machine tool products of dual purpose applied in the defence industry. Budget funding over the first stage, 2011–16 was set at 10.6 billion roubles; for the second stage to 2020 it was to be decided later (Government of the Russian Federation, 2014). In October 2014, the government approved rules for granting subsidies to compensate for part of expenditures on R&D associated with projects for the organisation of the serial production of machine tool and tooling products under the state programme (Ministry of Industry and Trade of the Russian Federation, 2014 October 30).

In March 2017, this state programme on the development of industry was amended. The specific sub-programme for the machine tool industry was replaced by a more substantial sub-programme, 'Production of the means of production' covering a much broader range of production technology but, as before, aimed at reducing the 'critical dependence' of strategic organisations of machine building and the defence industry on imported technology. Budget funding to 2020 of almost 61 billion roubles was envisaged. From the reports on the implementation of the programme and the fulfilment of its indicators it is not possible to judge the extent of its success.

At the end of September 2014 the government adopted a classified order (*rasporyazhenie*) on a plan for the support of import substitution in industry aimed at the organisation by the Ministry of Industry and Trade (Minpromtorg) of work for forming plans of measures to be adopted in civilian branches of industry. The branch import substitution plan for the machine tool industry appeared on 31 March 2015 (Import substitution plan, 2015). Work was to be overseen by the Ministry's Department of metallurgy, machine tool building, and heavy machine building (Newline, 2021). Projects for import substitution could become eligible for state support through the Russian Fund of Technological Development, a fund formerly under the science ministry but transferred to the Ministry of Industry in August 2014 as the Industrial Development Fund with the aim of providing support for the implementation of industrial policy, including import substitution. The

Fund provides loans at low rates of interest, 1%, 3%, or 5% for up to seven years (Industrial Development Fund, 2016). The plan of measures for the machine tool industry set targets for reducing the share of imports in annual installations of new machines by type of machine, in each case indicating the 2014 share and a maximum possible import share by 2020 (Table 1). But the plan did not include any measures to promote its implementation apart from mention of the Fund.

It will be seen that for large proportion of the types specified import dependence was set to remain at 60% or more in 2020.

In order to provide incentives to secure the implementation of the plan the government and the Ministry of Industry held a number of high-level meetings and adopted a series of measures to support enterprises active in developing Russian-built machine tools. In September 2015, the Ministry of Industry created an inter-agency working group for reducing the dependence of the machine tool and tooling industry on imports of equipment, components, spares, and services of foreign companies and the use of foreign software, and also for the development of the machine tool industry of Russia. The working group has been chaired by the director of the department of machine tool building of the Ministry, then Mikhail Ivanov, with other leading official of the department as its members, plus by agreement a number of other official and machine tool industry representatives, including the general director of 'Stankoprom', the rector of 'Stankin', the president of the business association 'Stankoinstrument', and leading figures of the missile-space and nuclear industries, plus the 'Skolkovo' science fund.

One of the most significant measures adopted in the new situation of sanction was a government decree of 17 July 2015 on a procedure for confirming that industrial products are produced on the territory of the Russian Federation. This decree, soon widely known simply by its number '719', has been amended many times since its adoption. It established a points system and when a certain threshold has been achieved the product is awarded a certificate confirming that it is 'Russian' and eligible for

Table 1. Plan for import substitution of metal cutting machine tools, 2015–20 (March 2015).

| Type of metal cutting machine tool | Import share of consumption In 2014%) | Maximum planned import share by 2020%) |
|---|---------------------------------------|--|
| Lathes, NC | 90 | 60 |
| Lathe-milling machining centres | 95 | 80 |
| Carousel lathes | 85 | 57 |
| Ultra-precision lathes and milling machines, NC | 100 | 53 |
| Horizontal boring machines | 80 | 61 |
| Coordinate-boring machines | 99 | 84 |
| Vertical milling 5 coordinate machining centres | 90 | 69 |
| Vertical milling machines, NC | 90 | 59 |
| Horizontal milling machines, NC | 80 | 59 |
| Portal and bridge milling machining centres | 100 | 63 |
| Coordinate grinding machines | 97 | 85 |
| Ultra-precision surface grinders | 98 | 84 |
| Ultra-precision circular grinders | 98 | 83 |
| Thread grinding machines | 97 | 73 |
| Ultra-precision sharpening machines | 100 | 73 |
| Gear milling machines | 99 | 71 |
| Gear grinding machines | 99 | 67 |
| Gear shaping machines | 99 | 75 |

NC - with numerical control unit.

Source: Import substitution plan (2015).

participation in special investment contracts as a means of increasing their production. For machine tools, the level of points varied depending on the type of machine, with the threshold level rising over time. Thus for NC lathes the level was 70 in 2020–21, 77 in 2022–23 and 85 in 2024–25, but for more advanced lathe-milling machining centres 95, 105 and 115, respectively. The most complex of all were considered to be 5-axes horizontal milling machining centres, 100, 110, and 120, recognising the difficulty of achieving the status of a ‘Russian’ machine (Technology Localization Center, 2015). Since this decree was first adopted the websites of machine tool building companies have proudly documented the certificates gained by their products making them eligible for a range of benefits, not least inclusion in government procurement contracts, including those relating to the defence industry.

The next significant government intervention was a meeting in March 2016 of the presidium of the Presidential council on the modernisation of the economy and innovation devoted to the development of the machine tool industry. This brought to prominence a major new actor. The meeting was held in Kolomna at the ‘Stankotekh’ company of the new machine tool-building firm, the ‘STAN’ Group, discussed above. At the meeting, chaired by prime minister Dmitrii Medvedev, Sergei Nedoroslev, founder of ‘STAN’, was one of the lead speakers, together with industry minister Denis Manturov and Vsevolod Opanesenko, the general director and founder in 2002, of one of Russia’s most successful, innovative, high-technology companies, ‘T-Platformy’, a major developer and builder of supercomputers. Later this company, which began to develop NC systems, became involved in legal trouble, with Opanesenko charged with financial abuses and in September 2022 declared bankrupt, soon followed by the bankruptcy of his company (C News, 2022). Also in attendance were several government ministers, many leading figures of the machine tool industry and the director of one important defence industry customer, the ‘Krasnoyarsk machine building works’ (‘Kras mash’), a major producer of ballistic missiles, at the time undergoing re-equipment as preparation for building the new ‘Sarmat’ heavy, multi-warhead, ICBM (Medvedev & Manturov, 2016). Also in March 2016 procedures were adopted to provide budget subsidies via the Russian Fund for Technological Development to help finance projects for the development of the serial production of new machine tools, with particular emphasis on import substitution (Government of the Russian Federation, 2016). By the summer of 2016 the development of the machine tool industry had risen up the priority ranking for government attention, not least because of the equipment needs of the defence industry then receiving a significant volume of funding for the expansion and upgrading of its production capacities.

The benefits of having a certificate confirming ‘Russian’ status were enhanced in January 2017 with a new government decree stopping the purchase of foreign products for defence or security-related purposes if a Russia product of the same type was available from a domestic supplier. This measure provided protection from foreign competition for companies achieving success in import substitution. However, it did not apply to products of members of the Eurasian Economic Union, giving producers in Belarus equal status to those in Russia. It was also extraordinarily ambitious to the extent that it probably generated concern within the defence industry as the quite long list of types machines not to be imported included machining centres, advanced lathes and many types of grinding machine (Government of the Russian Federation, 2017).

Table 2. Amended plan, 2017, for import substitution of metal cutting machine tools to 2020.

| Type of metal cutting machine tool | Import share of consumption In 2014(%) | Maximum planned import share by 2020(%) |
|--|--|---|
| Lathes | 93 | 70 |
| Carousel lathes | 85 | 57 |
| Boring machines | 90 | 75 |
| Milling machines | 90 | 60 |
| Portal and bridge milling machining centres | 100 | 63 |
| Coordinate grinding machines | 97 | 85 |
| Machine tools for other types of finishing of metals | 100 | 55 |
| Ultra-precision machine tools | 100 | 73 |
| Gear processing machines | 99 | 71 |
| NC systems | 65 | 20 |

Source. <https://legalacts.ru/doc/prikaz-minpromtorga-rossii-ot-31032015-n-650-ob-utverzhenii/>, accessed 26 June 2023.

In December 2017, the March 2015 plan for import substitution in the machine tool industry was updated and its targets amended, as shown in [Table 2](#).

It will be seen that the plan is much less detailed than the original 2015 version, perhaps a deliberate move to classify information considered sensitive.

Perhaps in recognition of the difficulties in implementing the January 2017 decree stopping the import of a wide range of products for use in the defence industry, in March 2019 a similar decree appeared for the machine tool and tooling industry only with a sharply narrowed range of types of machines: lathes, boring and milling machines, those cutting by laser, ultrasound or similar, plus machining centres but in general terms, without any specification of their complexity (Government of the Russian Federation, 2019). In the following year, this new shorter list was incorporated into yet another decree specifying many types of industrial goods not to be imported for the needs of the MOD and the security services (Government of the Russian Federation, 2020b). This decree in reality replaced all the earlier ones of a similar type and soon became known in the branch as ‘616’.

A major development came in November 2020 when the government approved a Strategy for the Development of the Machine Tool and Tooling Industry during the Period to 2035 (Government of the Russian Federation, 2020c). This 35-page document first provided a brief profile of the industry and then formulated a strategy with three scenarios: an ambitious one with innovation, basic, and conservative. It noted that the volume of consumption of machine tools was relatively stable, at 70 billion roubles a year, 2014–19, with domestic production increasing from 10.4 billion roubles in 2014 to 16.7 in 2019. It was a segmented market, enterprises of the defence industry accounting for approximately 70% of the consumption of machine tool and tooling products and the top priority for state procurement, and the civilian sector of industry, 30%. A central problem of the Russian machine tool industry was identified as its dependence on imports for key precision components, with 80–95% of the consumption of spindles, ball circulating screws and guideways being imported. There was some domestic production but in small batches with insufficient quantity and quality for high-technology equipment (Government of the Russian Federation, 2020c, pp. 4–13).

The strategy was designed to address the fundamental problems of the industry: ‘The current level of the technological and socio-economic state of the machine tool and

tooling industry in Russia provides evidence of a complex situation in the branch, that is characterised by a lack of competitiveness of enterprises, a low technological level of products, and an shortage of skilled personnel, confirmed by its market indicators. Despite the positive dynamic of output in natural terms, on the whole the level of import dependence is critical for the majority of positions. Inadequate competence in the production of components significantly limits the development of the branch.’ (Government of the Russian Federation, 2020c, pp. 20–21). The aim of the strategy was to secure long-term growth of production, in the basic scenario from 34.5 billion roubles in 2020 to 51.5 in 2025 and 79.5 in 2035 with an increasing share of localisation, from 48% in 2020 to 55% in 2025 and 70% in 2035. But the share of machine tool imports would still be significant, declining from 76% of consumption in 2020 to 70% in 2025 and 62% in 2035. But in the defence industry the share of imports would be lower. Details were not provided but it was stated that in civilian branches the share of Russian products would increase from 18% to 38–40% by 2035. There does not appear to have been any plan to put the strategy into action but a year later its main targets to 2030 were incorporated into the second sub-programme of an updated version of the state programme ‘The development of industry and raising its competitiveness’, entitled ‘The development of the production of means of production’, reflecting the title of the relevant department of Minpromtorg at the time of its adoption (Government of the Russian Federation, 2021).

In relation to all these measures the Ministry of Industry probably found itself in a difficult position. Charged by the government with advancing import substitution in the defence sector and other strategic branches of the economy, it was probably keenly aware that within the defence industry there was considerable doubt as to the ability of domestic machine tool builders to meet their needs. Various subsidies and incentives were made available to promote the take up of domestic equipment, in particular under decree No.1206 budget subsidies to domestic machine tool builder making it possible to offer discounts to purchasers of their products. The types covered were machining centres, lathes, boring and milling machines, plus some precision components, including spindles, guideways, and tool magazines (Government of the Russian Federation, 2020a). A few days before the start of the war this decree was amended, the main change being the addition of NC systems to the list of products (Government of the Russian Federation, 2022b).

In June 2021 Minpromtorg issued a new plan of measures for import substitution in the machine tool and tooling industry, with domestic shares of the market before the plan, presumably 2020, and by 2024. As can be seen in Table 3 this was even less detailed than

Table 3. Plan for import substitution of metal cutting machine tools, 2020 –20 June 202421.

| Type of metal cutting machine tool | Domestic share of consumption In 2020%) | Domestic share by 2024%) |
|---|---|--------------------------|
| Lathes, boring and milling machines | 25 | 33 |
| Machine tools processing metals by laser, machines of a similar type; machining centres and similar | 32 | 42 |
| NC systems | 10 | 22 |
| Spindles | 15 | 23 |
| All components for machine tools | 15 | 35 |

Source. <https://frprf.ru/download/plan-po-importozameshcheniyu-v-stankoinstrumentalnoy-promyshlennosti>. pdf, 28 June 2021.

earlier plans but revealed that the industry had not met the targets set earlier and still had a very long way to go.

Perhaps because of the measures taken since the 2014 sanctions, over time scepticism within the defence sector in relation to domestically built machine tools appears to have weakened, perhaps aided by the fact that to an increasing extent the producers were defence industry companies or within state structures such as 'Rostekh'. But by 2021 the sense of urgency also seems to have diminished, perhaps reflected in the targets set for 2024 in the June 2021 import substitution plan. This was the final measure relating to the branch before the military action of 24 February 2022.

How were all these policy initiatives received by the machine tool industry? On the whole positively, it appears, but not without some criticism. This was made clear in an informative discussion of import substitution in 2021 featured by the journal *Ekspert. Metalloobrabotka*.

The assessment of the leaders of companies orientated mainly to the needs of the defence industry and other priority customers was more positive than of those serving the market and general and endeavouring to export their products. The then general director of 'STAN', Denis Polevchikov, emphasised that the company had no interest in exports as its priority was the meeting the demands of domestic clients seeking high technology machines geared to their specific requirements. But these machines built in Russian conditions was very costly, more so than similar imported products. So, for 'STAN' measures reducing the price for customers were a priority.

The sales director of 'DGM-Mori Rus', Rustam Alyatdinov, considered that the measures failed to take adequate account of the difference between the demands of 'budget enterprises', i.e. defence industry plants and other state supported companies, and the general commercial market on which his company was mainly focused. For the former, import substitution was important as it was a condition for their involvement in public procurement contracts, but it was not important for the latter as customers wanted quality, reliability and high technology at an acceptable price and this often meant imported components. This stance was also backed by Ivan Aver'yanov, chair of the board of directors of 'PZMTs' who argued that import substitution raised the cost of their machines but did not advance technology. Indeed, because the criteria according to which machines were regarded as 'Russian' were not upgraded frequently, using the latest components such as spindle motors could reduce the number of points awarded meaning that a machine incorporating such components became 'less Russian' but was in fact more advanced technology. There was general agreement that the procedures enforced by Minpromtorg under decree 719 were far too bureaucratic and time consuming.

In response, Valerii Piven', then head of the department of machine tool building and heavy machine building of the ministry, agreed that '719' had to be flexible and updated regularly and pointed out that customers could not be subsidised as against WTO rules, so instead was subsidising them via producers according to the above-mentioned 2020 decree No.1206. He agreed that the situation of companies with an export orientation and those serving the domestic market varied and for the latter, especially supplying the budget sector it was vital to be prepared to respond rapidly in the event that sanctions were imposed. He was firm, 'on this issue I am categorical', you must fulfil the conditions of localisation. The exchange of views not long before the events of 2022 left little doubt

that for the government meeting the needs of the defence industry for machine tools was the overriding priority (Ekspert Metalloobrabotka, 2021). It is instructive to examine developments in the machine tool industry between 2014 and the beginning of 2022.

Developments in the machine tool industry during the years 2014 to 2021

Having reviewed the evolution of policy, let us now consider the role of the defence industry itself as a producer of machine tools. This is important as it has been one of the most significant developments in efforts to rebuild the Russian machine tool industry in recent years. As noted in the introduction, the building of advanced machine tools has been an activity of some enterprises of the defence industry since the foundation of the domestic industry in the 1930s and continued until 1991 and beyond. During the 1990s and 2000s as demand fell some defence companies stopped building machine tools and other continued but on a very modest scale or switched to other related activities. A good example of the latter is the leading producer of strategic missiles, the Votkinsk machine-building works, in Soviet time a major manufacturer of milling machines and from 1982 advanced machining centres (Stanki Katalog, 2018). It continued building milling machines on a modest scale during the 1990s but more recently has focused on progressive cutting tools for machine tools of a type meeting the needs of the defence sector and other advanced instrumentation (Korogodskii et al., 2016).

Another important defence industry machine tool builder, 'Tulamashzavod', building milling machines from 1931, almost ceased after 1991 but in 2013 decided to renew machine tool building and created a specialised daughter enterprise, the science-production enterprise 'Stankostroitel'nyi zavod Tulamash' devoted to building NC milling machines and lathes. From 2018 it started building a 5-axes gantry milling machining centre. A strong design group has been assembled, now working on the development of a 6-axes lathe machining centre. The factory looks like once again becoming an important centre for the building of advanced machine tools, focusing on high-precision and ultra high-precision equipment, i.e. the types covered by sanctions (CNC Tulamash, 2018).

One of the most interesting and promising new developments was in Perm', the 'Permskii zavod metalloobrabatyvayushchikh tsentrov' (PZMTs). This is a new enterprise created in 2014, the initiative of one of the country's leading builders of rocket engines, Perm' 'Proton-PM', part of the vast Perm aero-engine building complex. It investigated the possibility of machine tool building from 2011 and in 2014 began to build the 'Proton T630G' NC lathe and then a NC lathe machining centre, the 'Proton T500', both claimed to be of original design and the latter registered as Russia-built product. A separate joint stock company was established, AO 'Sovmestnoe tekhnologicheskoe predpriyatie "Permskii zavod metalloobrabatyvayushchikh tsentrov"'. This was a joint project of 'Proton-PM', the 'Prom-Oil' company and 'Stankoprom' of 'Rostekh' (Bezformata, 2015). Initially 'Prom-Oil' held 100% of the shares and 'Stankoprom' a single share, but in 2016 'Proton-PM' acquired a stake of no more than 5–6% (Emelyanova, 2016).

In 2017 additional production capacity was added and in 2019 a milling machine, the 'Photon' series, was added to the product range (PZMC, 2023a). By 2021, the company had now a well-established producer of multifunction 3 and 4 axes machining centres of increasing technological sophistication finding application in a number of branches of the defence industry and in civil machine building (Sdelano u nas, 2020). It has a youthful

staff, including a number of women in senior posts; indeed, for some time its general director was Tat'yana Fadeeva (PZMC, 2020, 2023d).

Another example is the Kovrov elektromekhanicheskii zavod, a major manufacturer of hydraulic systems for artillery and other weapons belonging to the 'NPO "Vysokotochnye komplekсы"' holding company of Rostekh, the products of which include the 'Iskander-M' operational missile system, the 'Pantsyr' air defence systems and the "Kornet" anti-tank weapon. This experienced high-precision machine builder in July 2013 signed an agreement with the Takisawa company (Japan and Taiwan) to assemble TS-400 NC lathes under licence. The agreement gives the Kovrov company an exclusive right to the their assembly, sales and service. The intention was to build up to 650 machines a year and then increase the volume to 1,700 by involving other enterprises of Vladimir oblast', with a widening range of high-precision machine tools equipped with Russian-built, highly secure, control systems, and a progressive localisation of supply. This was to become a machine tool building cluster based on KEMZ, building new 5,000 square metre production shop to become operational in 2019. To 2024 about 460 million roubles was to be invested in the cluster. In 2018 50–60% of the components used in building machine tools at KEMZ were manufactured in Russia and the aim was to reduce the share of foreign components to 10% by 2026 (Kemz, 2018; Sdelano u nas, 2014). The Kovrov works is now building high-precision lathes and 5-axis milling machining centres of console and gantry types, the KVS KT5 and PT5, fitted with Russian 'Olimp' NC systems designed to have a very high degree of information security (Valeeva, 2018).

This is not the first example of the machine tool building of a defence company becoming the core of a new cluster. The pioneer was the leading St Petersburg enterprise 'Kirovskii zavod', which became involved in machine tool building in the late 1990s and established a machine tool-building business, 'Kirov-Stankomash', in 2004. It began with the repair and modernisation of metal working equipment and the progressed to the manufacture of a range of gear cutting machine tools, aided by a group of specialists invited from the long-established Saratov factory of heavy gear cutting equipment. It then went on to develop the manufacture of spindles, aided by specialists formerly working at the pioneer Soviet machine tool factory, the Leningrad imeni Ya.M. Sverdlova works (KSM, 2018). This famous enterprise, privatised in 1996, became the 'Sverdlov' machine tool building company, but in 2004 closed down and its premises were sold off. However, its 'Technicheskoe byuro stankostroeniya', established in 1994, the core of its design and engineering capability, managed to survive as an independent unit and in 2009 became the 'Stankozavod TBS' company, keeping alive the traditions of the 'Sverdlov' works. In March 2012, on the initiative of the Kirovskii zavod, it was decided to create a machine tool-building cluster in St Petersburg, with a management team headed by Yulia Adashkevich, who earlier worked for many years at the imeni Ya M. Sverdlova works, ending up as a deputy general director. Founder members included 'Kirov-Stankomash', 'Stankozavod TSB', 'Balt-Sistem', the leading Russian producer of control systems for machine tools, and the 'Sankt-Peterburgskii zavod pretsionnogo stankostroeniya', in Soviet times the 'Zavod imeni Il'icha' building grinding machines (Kirov Plant, 2012; ZPS, 2023). This cluster has developed steadily since 2012, still headed by Adashkevich, a vigorous supporter of building

machine tools of original Russian design and a scathing critic of presenting assembled foreign machines as 'Russian', in her view 'pseudo-import-substitution' (Adashkevich, 2018). According to her, in its first five years the cluster, made up entirely of small and medium companies, supplied goods and services to a value of 15 billion roubles and built over 300 machine tools of original design, including machining centres, precision machine tools, gear cutting machines and hydraulic presses, plus many components and systems for machine tools (Adashkevich, 2018). In 2018 'Stankozavod TSB' relocated to new production facilities for building heavy machine tools and machining centres in cooperation with other firms of the cluster (Promreg, 2018). As of mid-2018 the cluster included 25 enterprises and working with 'Rostekh' is establishing an 'International Centre of Technological Innovation' to develop heavy machine tool building and cooperation with Belarus (Koval'chuk, 2018).

A different approach has been adopted by the state corporation 'Rosatom', which by 2021 had emerged as a significant machine tool producer. It provides an interesting example of close business cooperation between a private company and state structures of the nuclear weapons industry and companies engaged in machine building for the nuclear power industry. This initiative pre-dates the imposition of sanctions and was part of an effort to diversify the nuclear weapons industry by increasing its activities relating to the civil economy. However, the imposition of sanctions clearly focused efforts and gave a new impetus to the project. A key actor is the St. Petersburg 'Baltiiskii promyshlennaya kompaniya' ('BPK'), a private company established in 2002 to supply imported machine tools to the Russian market. Over time it developed close relations with many leading foreign companies, often with exclusive rights, and offered a very comprehensive service to customers. It began to engage in repairs, modernisation, and assembly, and in 2013 signed agreements with a number of leading foreign companies to produce their machines under the brand names 'F.O.R.T' (Force, Opportunities, Russian Technologies), adopted in 2014, with its machines supplied under a distinctive white, black and red livery (Fort Russia, 2023).

The first enterprise to establish relations with 'BPK' was the 'Priborostroitel'nyi zavod' ('PSZ') of the nuclear weapons industry, located in the closed city of Trekhgornyy, Chelyabinsk oblast'. This major facility of the industry was established by a government decision of 1952 for the production of nuclear munitions. It was here that on the initiative of its then director, Mikhail Pokhlebaev, in 2011 a project to develop machine tool building was launched in response to a 'Rosatom' demand for an increased output of civilian goods from enterprises of the nuclear weapons industry. 'PSZ' responded by establishing cooperation with the Sterlitamak machine tool company, a long-established builder of NC lathes, milling machines and other types. In the first year 'PSZ' assembled 20 machines but the Sterlitamak works ran into financial problems and the cooperation ceased. In 2013–14 'PSZ' assembled machine tools from Indian components and then entered into a partnership agreement with 'BPK', with the status of integrator for Rosatom for its machine tool-building activities. From the outset it was envisaged that there would be progressive localisation of supply of systems and components. From late 2014 Pokhlebaev became director of another leading enterprise of the nuclear weapons industry, 'Mayak of the Ozersk closed city, Chelyabinsk oblast', and it soon became involved

in the 'Rosatom' - 'BPK' 'Stankostroenie' programme, creating capacity on the site of its reactor factory, building its first machine tool in 2015 (Rudyaeva & Tripoten', 2016).

This programme developed quite rapidly and engaged an increasing number of Rosatom enterprises, of both the nuclear weapons industry and 'Rosatomenergomash' the state corporation's nuclear engineering division. Enterprises of the former include 'Start' imeni M. V. Protsenko of the Zarechnyi closed city, Penza oblast', 'Sever', Novosibirsk, a producer of electrical equipment, the "Elektrokhimpribor" Kombinat' of the Lesnoi closed city, and more recently, the Nizhni-Novgorod NIIS imeni Yu. E. Sedakova (NII izmeritel'nykh sistem), an important centre for micro-electronics developing control systems for nuclear power stations and other nuclear installations. Nuclear engineering enterprises include 'Petrozavodskmash', which has significant foundry capacity, now casting machine tool beds and other components for many companies, including Rosatom, 'BPK' and the 'STAN' group. 'PSZ' is now making a range of different models including grinding machines, plasma cutting machines, and horizontal boring machines (Rosatom, 2016).

The range of machine tools built by Rosatom enterprises steadily widened. 'Start' of Zarechnyi cooperated with the well-established Srednevolzhskii stankostroitel'nyi zavod, a producer of precision lathes, to build the SAMAT-400 'Vektor' NC lathe. Components were supplied by the Srednevolzhskii factory but all finishing work undertaken at 'Start'. It was decided to localise supplies of components with 'Start' gradually expanding its capabilities. With a strategic partnership, design work was undertaken on new lathe models of the ultra-precision class (Srednevolzhsky Machine Tool Plant, 2018). 'Mayak' began building machines of the F.O.R.T range, including 5-axis machining centres and gantry lathes. NIIS imeni Yu.E.Sedakova, the leading producer of radiation hardened integrated circuits and other electronic components vital to the manufacture of strategic weapons, began making 'Sfera' systems with a Russian element base (Rosatom, 2022). 'Sever' focused on electric motors and drives, while the 'Elektrokhimpribor' combine started the production of components for 'F.O.R.T' machines but in time was to develop full assembly.

With the imposition of sanctions on advanced machine tools in 2014 developments speeded up. 'STAN' started building multi-axes machines of various types and other high productivity machine tools, mainly for the defence industry. However, with very long lead times the company ran into financial difficulties and became increasingly dependent on 'Novikombank', the bank of 'Rostekh'. In 2021 'Rostekh' took over 'STAN' and converted 'Stankoprom' holding into a larger new one, 'Mekhanika', focused on the development and building of a wide range of advanced machine tools, especially those vital to the defence industry (Rostec, 2022; Sidorkova, 2021). Since 'Mekhanika' was founded it has received very little publicity and this also applied to 'STAN' in 2022, but as related below this began to change in 2023.

In addition, the country's principal builder of strategic missiles, the Votkinsk machine-building factory ('Votkinskii zavod'), as noted above in Soviet times also an important machine tool builder producing more than 50,000 from the early 1950s to the mid-2000s. In 2011, it started development work on new models of machining centres and more recently has started making components for advanced machine tools and is set to become a leading builder of multi-functional lathe-milling machining centres for the needs of the missile-space industry and more widely (Rusanov, 2021).

Developments since February 2022

Not surprisingly, the imposition of sanctions prompted some new official measures to protect the domestic machine tool industry and more are set to come. As the regime of sanctions intensified import substitution became more urgent but not easy to implement at short notice and it was easier for Russian companies to seek alternative sources in non-sanctioning countries. One of the first measures was a decree outlining a procedure for importing equipment needed for priority investment projects without the payment of import duties, the branches of the economy listed included those relating to the defence industry. This appears to be a measure facilitating imports from new supplier countries, including so-called parallel imports in relation to machine tools and other products (Government of the Russian Federation, 2022c). In December, it was decreed that the main types of machine tools, plus NC systems, purchased for state needs, including defence and security, would be eligible for payments in advance of up to 80% of the value of contracts concluded during 2022–24 (Government of the Russian Federation, 2022a). There may have been other measures but they are not shown on the informative website of the 'Stankoinstrument' Association. In July 2023 incentives to purchase Russian high-technology equipment were reinforced by a measure reducing the tax on business profits for those companies buying certain products listed in a government order. These included most types of NC machine tools – machining centres, lathes, drilling, boring, milling, threading, and grinding machines with specified high technology characteristics, namely three or more controlled axes and a certain level of precision. Machines were eligible only if they were included in the official register of Russian industrial products (Ministry of Industry and Trade of the Russian Federation, 2023).³

A possible new government initiative to develop the industry has been under discussion for some time, a federal project, 'The development of the machine tool and tooling industry'. The leader of the Association 'Stankoinstrument' Georgii Samodurov referred to it on several occasions in 2022 and 2023, saying that the Association was actively involved in its drafting, with overall leadership in the hands of deputy premier Dmitrii Chernyshenko, with the involvement also of Denis Manturov. It is perhaps worth noting that Chernyshenko, like prime minister Mikhail Mishustin, is a graduate of Stankin, so familiar with machine tool issues.⁴ Samodurov claimed that this was the first time during the past 25–30 years that there has been an attempt to resolve a whole set of issues facing the branch on a comprehensive basis, including the stimulation of demand for domestic products, the creation of new and modernisation of existing production capacities, grants for small businesses and start-ups, standardisation and R&D (Samodurov, 2023).

In February 2023 Manturov and Chernyshenko jointly led a meeting to discuss the work on drafting the federal project stressing the importance of using already existing range of mechanisms for supporting the industry but warning that any additional financial support would have to be carefully substantiated given the 'present realities'. Working groups were continuing to consider various aspects of the project and Chernyshenko indicated that the next stage would be an assessment of the resources needed to fund it (Manturov & Chernyshenko, 2023). In March, visiting Belgorod oblast', Manturov said that the development of machine tool industry was receiving special attention and that work on the federal project would be completed in the second quarter of the year. A number of working groups involving more than

four hundred experts were formulating proposals for the final version (Manturov, 2023). It is not known when work on the federal project will be completed or whether when finalised it will be published. However, it does appear to represent a new level of dialogue between government and industry of the type observed by Yakovlev and fellow researcher studying how the Russian economy has been adapting to the challenges of recent years, from the 2014 sanctions, the coronavirus pandemic, to the war and heightened sanctions (Yakovlev, 2023). Finally, a sign that the industry had risen far up the policy agenda was a report at the end of August 2023 that the Security Council had presented President Putin with proposals for the development of the machine tool industry. The secretary of the Council, Nikolai Patrushev, said that the report had received the backing of the President and the government was giving the matter very serious attention (Finmarket, 2023).

Developments in the machine tool industry since February 2022

Since the imposition of tough sanctions in 2022 the fate of some of new initiatives of earlier years remains unclear. U'lyanovk 'DMG-MORI', the largest new producer of modern general purpose machine tools, closed down the Japanese-German company knowing that some of the machines built could be used in the defence industry took the action to avoid potential sanctions (Factories.ru, 2022). The 'Mekhanika' holding of Rostekh clearly remains very active, but it is not known what has become of the activity of 'Rosatom' as the building of some of its 'FORT' machines was probably dependent on quite a few imported inputs. It may be significant that the website (<http://www.imf.ru>) of one of its main producers, Priborostroitel'nyi zavod imeni K. A. Volodina ('PSZ') in the nuclear weapons closed city of Tryokhgornyi, Chelyabinsk oblast' is now inaccessible, while that of another, 'Start' imeni M. V. Protsenko (PO 'Start') of the Zarechnyi closed city, Penza oblast', no longer includes machine tools in the products listed on its site but does include a range of cutting instruments for them (Start, 2023). However, machine tools still feature in the 2023 edition of 'Rosatom's catalogue of civilian goods produced by its enterprises, including those of 'PSZ' and PO 'Start', and also machine tools supposedly available from 'Rosatom's' Moscow 'branch integrator' and distribution centre for machine tools, 'IPN Stankostroenie', in particular a wide range of machines, including advanced machining centres, NC lathes and grinders, built by the Czech 'Kosovit MAS' company. Indeed, the website of 'IPN Stankostroenie' (IPN, 2023) perhaps not updated for some time, shows the imported machines but the section devoted to Russian-built equipment is empty. The company claims to have supplied machine tools to more than 2,000 enterprises and to hold a stock of spare parts for them (Rosatom, 2023). The catalogue also includes 'Sfera' NC systems produced by NIIIS imeni Yu. E.Sedakova of Nizhnii Novgorod, claimed to be fully protected from any unauthorised use and based entirely on Russian components and software (Rosatom, 2023). Finally, the large, versatile and well-equipped foundry 'Petrozavodskmash' in Karelia, part of the 'Atomenergomash' division of 'Rostom' still includes the casting of machine tool beds and other components among its activities, hinting that perhaps the state corporation is still building machine tools but prefers not to publicise the fact (Foundry Plant Petrozavodskmash, 2023). However, as shown in the following section, analysis of quantitative data suggests that Rosatom's machine tool building may have come to an end.

It is also possible that 'KEZM' and 'Tulamashzavod' are encountering difficulties as by early 2022 they had probably not fully localised the production of their advanced machining centres based on Taiwanese and Japanese models, both countries having imposed sanctions. Before the latest sanctions many NC machines were fitted with imported control systems, often Fanuc, and Siemens, and while the range of Russian control systems is increasing the volume of production may be lagging behind demand, partly because of difficulties in obtaining the needed electronic components. However, new companies have been emerging often claiming that their products are fully up to modern standards, including 'Balt-sistem' of St Petersburg, 'Mekhatroninka' of Ivanova and an increasingly prominent Moscow company, 'INELSI', with its 'IntNC PRO' systems now being used by a number of machine tool builders, including 'KEMZ' for some of its advanced machining centres (Inelsy, 2022a, 2022b; Zen, 2022).

One company is still very much in business, the leading producer of advanced machine tools 'STAN' under the 'RT-Kapital' investment company of the 'Rostekh' state corporation. Indeed, in 2023 after quite a long period of inactivity its website was renewed and once again news items began to appear. A new general director was appointed in February, Boris Bogatyrev, with many years experience of management in the machine-building industry, including some time as general director of 'Metrovagonzavod', Mytishchi, the country's principal manufacturer of rolling stock for underground railways and a producer of tracked vehicles for army air defence systems, so familiar with military technology (Ageikin & Spasskii, 1996; Stan Company, 2023b). 'STAN' continues to build new machine models, including a large high-precision portal machining centre designed specifically for producing high technology machine tools, equipped with a Russian NC system, and another for very high precision machining of complex work pieces such as the turbine blades of gas turbine engines (Stan Company, 2023e, 2023f). Import substitution is clearly a high priority and working with a long-established company 'Tsentr effektivnykh proizvodstvennykh reshenii' (TsEPR) engaged in the repair of machine tool components now has its own manufacture of high-speed spindle motors essential to advanced machining centres, TsEPR gaining experience in the field having had an earlier agreement with the Swiss Fischer spindle company (CEPR, 2023; Stan Company, 2023d). But 'STAN' has also been strengthening its links with machine tool building in 'friendly' countries, in particular China. In May 2023, it signed an agreement with the Chinese HCNC corporation to cooperate in the production of 5-axes NC system and robotics and it was reported that the first group of specialists of the Russian company had already exchanged experience with HCNC colleagues (Stan Company, 2023a). In July, representatives of 'STAN' and one of its production sites 'Ryazan' stankozavod' went to China investigate potential partners and visited eight companies producing machine tools and components. It is expected that joint projects will be developed in Russia (Stan Company, 2023c).

In early 2024 'STAN' reported that more than 70 machine tools had been built in 2023 at the five factories of the group. The number may appear modest, but the company's output is of advanced high-productivity machines. During the year another producer had been acquired, the Lipetsk 'RT-Stankoinstrument' works specialised in the building of grinding machines. According to general director Boris Bogatyrev 'STAN' planned to double its output in 2024 and expand its range of products and components (Rostec, 2024, p. 10 January).

Another company that appears to be very active and increasing its volume of production, especially of types used in military production, is 'Kalashnikov'. Its latest catalogue offers a range of lathes, including NC models, milling, broaching, and deep drilling & reaming machines, the latter used for making gun barrels of various calibres (Kalashnikov inzhiniring (2024)). In 2023, the machine tool-building division of 'Kalashnikov' reported at 65% increase in output compared with 2022, built 126 units, including 45 precision '250ITVM' lathes used in particular in arms production, including the manufacture of 'Kalashnikov' machine guns (Kakashnikovgroup, 2024). It also started the production of high-precision spindles, replacing an important component previously imported from Italy and worked on fitting machine tools with domestically built NC systems (Kalashnikovgoup, 2023; Rostec, 2024).

In late 2022 a new initiative was announced in Kazan, the creation of a machine tool company 'Tatpromstan', led by a machine-building company earlier engaged in selling foreign machine tools, 'Pegas', headed by Il'dar Nuriev, and uniting 14 small companies. It assembled its first NC milling machine in April 2023 from a few of largely pre-assembled components and revealed a plan to build 30 in 2023 and achieve a level of localisation of up to 30%, rising to 500 units and 90% localisation by 2025 (Korobchenko, 2023). In June 2023, the Tatarstan industrial minister acknowledged that the components were imported from China. He also admitted that while the planned output for the year was 30, rising to 150 with 70% localisation in 2024, only two machines had actually been assembled. This admission helps to explain a sharp comment at a conference in early December 2022, when Nuriev revealed has plans for 'Tatpromstan'. An experienced director of another Tatarstan company, 'Zavod imenin Sergo' (producing refrigeration equipment), complained that they were leaving dependence on Europe and becoming dependent on China and Turkey instead, 'It is said that this is import substitution, but we are taking it from China. This is not import substitution, nothing of the kind!' (Vaganova, 2022). Certainly, in Tatarstan industrial interests generally appear to have considerable scepticism on the wisdom the becoming dependent on China and it would be interesting to know how widespread this view is in Russian industry more generally.

As noted above, promising newcomer after 2014 was 'PZMTs', the 'Permskii zavod metalloobrabatyvayushchikh tsentrov'. It developed to become a well-established producer of multifunction 3 and 4 axes machining centres of increasing technological sophistication. Its 2022 catalogue listed customers in 2018 to 2022, including 42 of the 115 total delivered to enterprises of the aero-engine conglomerate AO 'ODK', 29 to the aviation industry's 'OAK', five to 'Roskosmos', and three to the air defence group 'Almaz-Antei' (PZMC, 2022, p. 3). All its products are certified as Russian, most recently in 2022. A claim probably strengthened by the fact that the company now offers Russian NC systems, INELSI IntNC Pro or Mekhatronik MNC-800, presumably replacing the previously offered Fanuc and Siemens systems (PZMC, 2022, p. 15). It has its own design bureau, produces a widening range of components, including spindles, and offers a comprehensive service to customers from design, to installation, set up and maintenance, with a production capacity of up to 200 units a year (PZMC, 2023b). From a photograph on the company's well-organised website, 'PZMTs' has a youthful staff, including a number of women in senior posts, including its acting general director (PZMC, 2023c). Its website suggests a very active company but it cannot be ruled out that its activities have been affected by sanctions.

It is not clear what has become of the St Petersburg ‘Stankostroitel’ny zavod “TBS”’. Its catalogue advertises a range of NC multi-functional boring-milling-drilling machines, NC boring machines, and a few other types, but its website has virtually no news of developments since in 2022 and 2023 (TBS, 2023). The extent to which their building was dependent on imported systems and components is not known. Its machines could well be in demand as suited to the production of artillery systems and tanks guns so the lack of information may simply be military-related secrecy.

In 2023, there was a significant new development summed up in the title of a session of a conference in Perm’ in September 2023, ‘How they do it: the path from trade to production’, on the phenomenon in machine tool building of dealers turning into producers. Many foreign machine tool companies established dealer networks in Russia in the 2000s, staffed mainly by young Russian technical personnel and managers, who became very knowledgeable about machine tools, their manufacture, installation, and servicing. The main dealers often had large showrooms, stocks of spare parts and workshops for repairing and modernising older machines. It is probably not surprising that the ending of links with many foreign partners led to initiatives to find alternative sources of supply. One example is ‘DM Technologies’, a company established by some staff of the former DMG MORI factory and sales unit of Ul’yanovsk which began selling Chinese machines similar to the types they used to build and then started to build a machining centre, Cobalt T2, which has gained the status of a ‘Russian-built’ machine and will enter serial production in the first half of 2024. Initially, the majority of components will be made in China but with an active programme of import substitution. New milling machining centres are under development, one of 5 axes (Importozameshchenie, 2023; Titov, 2023).

More new companies have emerged. One is ‘Bivertekh’, building the Beavermill compact milling machining centre designed for cutting stainless steels and titanium. It is claimed that 800 of the components are made in Russia; 51 purchased in China (Bivertekh, 2024; Importozameshchenie, 2023). Another new company that started not in trade but in providing engineering services to clients and then developed the production of machinery for the foundry industry. SLT (*Sovremennye liteinye tekhnologii*), based in Moscow but with a regional service network, began building a range of high precision machine tools in 2000 and in 2023 was making lathes, boring, grinding and milling machines, including 5-axes models, and claimed to be supplying strategic enterprises, including those of the aerospace industry. It is not clear whether they are genuinely Russian-built or assembled from imported components (RITM, 2023; SLT, 2024). In the words of the director for development of the National Union of Suppliers of Equipment and Tooling for Metal Working (NSPOIM), Evgeniya Sadovichkina, speaking in autumn 2023, ‘Now is the golden five years of Russian machine tool building, when it is just the time to increase capacities and to begin production’ (RITM, 2023).

Production and import of machine tools in quantitative terms, 2013 to 2023

The general post-sanctions situation is best explored by examining output and import statistics, taking 2013, the year before sanctions were first imposed, as the starting point. Table 4 shows the output of metal cutting machine tools, 2013 to the end of May 2023.

Table 4. Output of metal cutting machine tools, 2013–23 (units).

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|-----------------------------------|------|-------------------|------|------|------|------|------|------|------|------|------|
| Metal cutting mc t | 2945 | 3345 ^e | 3367 | 4383 | 4495 | 4188 | 4224 | 4529 | 5458 | 7221 | 9269 |
| Lathes | 549 | 600 | 623 | 738 | 1038 | 1231 | 909 | 1020 | 1089 | 1088 | 1645 |
| Inc NC | 137 | 227 | 204 | 337 | 467 | 554 | 401 | 445 | 598 | 435 | 879 |
| % NC | 25.0 | 37.8 | 32.7 | 45.7 | 45.0 | 45.0 | 44.1 | 43.6 | 54.9 | 40.0 | 53.4 |
| Machining centres ^a | 10 | 83 | 171 | 202 | 232 | 304 | 447 | 379 | 424 | 281 | 301 |
| Drilling mcs | 1062 | 503-394 | 230 | 140 | 292 | 276 | 223 | 248 | 193 | 617 | 670 |
| Boring mcs | 2 | | 3 | 3 | 34 | 31 | 16 | 32 | 33 | 20 | 221 |
| Milling mcs | 223 | | 289 | 569 | 129 | 237 | 277 | 447 | 296 | 582 | 997 |
| Planers ^b | | | | | 482 | 657 | 749 | 770 | 967 | 1031 | 1294 |
| Finishing mc tools ^c | 974 | 1601 | 1868 | 2394 | 1919 | 1073 | 1919 | 2128 | 3125 | 3161 | 3424 |
| Thread & nut cutting | 2 | 3 | 6 | 43 | 42 | 23 | 2 | 3 | 4 | 8 | 7 |
| Laser & similar mc t ^d | 123 | 161 | 177 | 294 | 328 | 357 | 431 | 272 | 294 | 433 | 710 |
| Total NC la & mc c | 147 | 310 | 375 | 539 | 699 | 858 | 848 | 824 | 1022 | 716 | 1180 |
| % total | 5.0 | 8.0 | 11.1 | 12.3 | 15.6 | 20.5 | 20.1 | 18.2 | 18.7 | 9.9 | 12.7 |

^aMachining centres, unit machine tools, multi-functional machine tools

^bPlaners, shapers, and saws. Note for 2013–16 they must have been included with another type, probably milling machines.

^cSharpening, grinding, honing, and cutting off machine tools

^dLaser, ultrasound, and similar, removing metal by cutting

^eFor some unexplained reason, for 2014 the total given in the source and in Rosstat,

Promyshlennoe proizvodstvo v Rossii – 2016 g., Table 6.69 does not equal the sum by type of machine. Here this sum is shown, not 3,871 as given in the source.

Note: it is not clear where gear cutting machine tools are located, perhaps with milling machines.

Source: Rosstat official data, <https://fedstat.ru/indicator/57783> except for 2023, https://rosstat.gov.ru/enterprise_industrial, accessed 31 January 2024. Note, fedstat.ru not accessible from September 2023.

Developments in 2022 suggest that sanctions have had some impact but not to a very large extent. Indeed, the total output of metal cutting machine tools increased sharply in unit terms, 7,225 being produced, the largest total since the late 1990s. However, the number of advanced machines fell, 281 machining centres were built, a one-third decline, and 434 NC lathes, a 27% fall, probably explained by the closure of the Ulyanovsk factory, the country's leading producer of NC lathes. There were substantial increases in the output of drilling and milling machines, and a modest increase in grinding and other finishing machines. This suggests that some experts of the Association 'Stankoinstrument' may be right in their suspicion that Rosstat has inflated output by including some tools of a household type, in breach of an earlier Presidential assignment that the output of industrial and household cutting goods has to be reported separately (Karpova, 2023). Overall, the share of advanced machines in the form of machining centres and NC lathes in total output in 2022 fell from 19% in 2021 to 10%. It is possible that the reduced output was at least in part caused by difficulties in obtaining some vital components and suitable control systems as accumulated stocks of imported items were run down.

In 2023 output increased by more than 2,000 units and reached a level not achieved since the late 1990s. There were increases for all basic types of machine with a strong recovery in NC lathes but less so in machining centres, although their combined share of total output reached the 2016–17 level.

If sanctions had had a substantial impact on machine tool production one might have expected this to be shown by a changing regional distribution of output. As shown in Table 5 there have been changes but on the whole to a modest extent.

As can be seen, notwithstanding the closure of the Ulyanovsk factory of 'DMG-MORI' the share of the Volga federal district has slightly increased, but the shares of both the

Table 5. Output of metal cutting machine tools by federal district, 2021 to 2023.

| | 2021 | | 2022 | | 2023 | |
|----------------|--------|---------|--------|---------|--------|---------|
| | Number | % total | Number | % total | Number | % total |
| Central | 2 594 | 47.5 | 3 527 | 48.9 | 3 841 | 41.4 |
| North-West | 257 | 4.7 | 283 | 3.9 | 548 | 5.9 |
| South | 191 | 3.5 | 312 | 4.3 | 561 | 6.1 |
| North Caucasus | 19 | 0.3 | 21 | 0.3 | 369 | 4.0 |
| Volga | 815 | 33.3 | 2 454 | 34.0 | 3 281 | 35.4 |
| Urals | 135 | 2.5 | 160 | 2.2 | 165 | 1.8 |
| Siberia | 447 | 8.2 | 464 | 6.4 | 504 | 5.4 |
| Total | 5 458 | 100.0 | 7 221 | 100.0 | 9 269 | 100.0 |

Source. Calculated from data of https://rosstat.gov.ru/enterprise_industrial accessed 31 January 2024.

Urals and Siberian district have declined, perhaps providing evidence that the output of 'FORT' machines at enterprises of Rosatom has indeed fallen and possibly ceased altogether as the supply of components has ended. The largest increase has been for the North Caucasus federal district and relates to milling machines. It can probably be explained by increased production of the 'Tvait' machine tool factory, Kamensk-Shakhtinskii, Rostov oblast', which builds small-scale NC milling machines as part a wide range of equipment for cutting metals, wood, stone, and other materials.⁵

Since 2014 the pattern of imports of machine tools has changed. Whereas in 2013 Europe and the United States accounted for the majority of imports, there has been a significant shift to reliance on Asian suppliers, above all China. Thus in 2013 the US, Germany, Italy, Switzerland, Czech Republic, and Austria accounted for 55% of all imports in value terms but only 35% in 2021, but the four main Asian suppliers, China, Japan, Korea, and Taiwan 29 and 52% respectively, including China 8.4 and 23.9%, becoming by far the largest supplier. Detailed data are presented in Table 6.

In the case of machining centres, the shift has also been significant. In unit terms, in 2013 the US, Germany, Italy, Switzerland, and Czech Republic supplied 685 units, 31% of the total, but in 2021 283 units, 23%. Russia imported 1,349 units in 2013 from the four Asian suppliers, 61% and 804 in 2020, 64%. China's share rose sharply, from 7 to 24%, as shown in Table 7.

Imports of NC lathes exhibited a similar pattern, with China emerging as the principal supplier: 23% of total imports in unit terms in 2013 but 44% in 2021. The impact of the 2014 sanctions was significant. In 2013 Germany, USA, Italy, and the Czech Republic supplied 554 units of the total imported, 1,925, 29%, but in 2016 225 units, 15%, and in 2020 only 217, 11%. Taiwan and Korea, not imposing sanctions, remained strong suppliers throughout.

Russian official trade statistics are no longer appearing and Russia and Belarus have stopped supplying data to the UN Comtrade database. However, it is possible to use 'mirror' statistics, i.e. reported machine tool exports to Russia in both years, as show in Table 8. One Russian industry source has published data that appear to be authentic, as shown in Table 9.

It can be seen that there were very significant changes in the ranking of suppliers: in 2021 countries that imposed sanctions in the following year accounted for 68% of the top 10 total by value and 53% in unit terms, but in 2022 36/34% and, following Karpova (2023) who argues that imports from sanctioning countries fell sharply in the second half of

Table 6. Total Russian metal cutting machine tool imports 2010–2021, US\$ thousand.

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|----------|----------|----------|---------|---------|---------|---------|---------|---------|---------|
| Total | 1317,941 | 1409,463 | 953,672 | 725,744 | 850,255 | 982,194 | 909,826 | 863,991 | 989,161 |
| China | 111,320 | 95,133 | 60,558 | 71,903 | 114,046 | 139,637 | 145,979 | 171,025 | 236,903 |
| % total | 8.4 | 6.7 | 6.3 | 9.9 | 13.4 | 14.2 | 16.0 | 19.8 | 23.9 |
| Japan | 114,436 | 92,254 | 75,953 | 81,678 | 62,602 | 73,817 | 68,277 | 44,750 | 39,978 |
| Korea | 40,387 | 35,357 | 36,904 | 46,365 | 53,353 | 68,790 | 64,291 | 56,454 | 84,920 |
| Taiwan | 115,638 | 17,983 | 105,926 | 90,328 | 103,605 | 108,689 | 122,218 | 85,779 | 104,851 |
| Subtotal | 381,781 | 340,727 | 279,341 | 290,274 | 333,608 | 290,933 | 400,765 | 358,008 | 466,652 |
| % total | 29.0 | 24.2 | 29.3 | 40.0 | 39.2 | 29.6 | 44.0 | 41.4 | 47.2 |
| Germany | 309,413 | 404,033 | 271,869 | 162,103 | 185,137 | 192,227 | 172,120 | 179,396 | 155,716 |
| % total | 23.5 | 28.7 | 28.5 | 22.3 | 21.8 | 19.6 | 18.9 | 20.8 | 15.7 |
| Italy | 141,853 | 136,090 | 126,428 | 50,684 | 79,022 | 99,466 | 95,357 | 64,948 | 77,402 |
| Czechia | 95,972 | 117,537 | 73,025 | 41,529 | 33,966 | 38,099 | 38,566 | 43,857 | 47,156 |
| Austria | 36,957 | 24,657 | 19,117 | 14,781 | 19,132 | 12,256 | 17,717 | 33,482 | 13,189 |
| Subtotal | 584,195 | 682,317 | 490,439 | 269,097 | 317,257 | 342,048 | 323,760 | 321,683 | 293,463 |
| % total | 44.3 | 48.4 | 51.4 | 37.1 | 37.3 | 34.8 | 35.6 | 37.2 | 29.7 |
| USA | 77,286 | 69,918 | 29,319 | 27,880 | 28,649 | 55,953 | 27,994 | 25,599 | 14,942 |
| Switzlnd | 61,538 | 66,194 | 52,071 | 36,991 | 52,223 | 87,927 | 57,229 | 34,090 | 41,016 |
| Subtotal | 133,824 | 136,112 | 81,390 | 64,871 | 80,872 | 143,880 | 85,223 | 59,689 | 55,958 |
| % total | 10.2 | 9.7 | 8.5 | 8.9 | 9.5 | 14.7 | 9.4 | 6.9 | 5.6 |
| Belarus | 44,946 | 53,537 | 17,936 | 18,251 | 28,476 | 21,949 | 28,813 | 23,339 | 43,872 |
| Ukraine | 8,414 | 4,130 | 3,627 | 1,063 | 2,055 | 1,385 | 2,724 | 1,255 | 887 |
| Subtotal | 53,360 | 57,667 | 21,563 | 19,314 | 30,531 | 23,334 | 31,537 | 24,594 | 44,759 |
| % total | 4.0 | 4.1 | 2.3 | 2.7 | 3.6 | 2.4 | 3.5 | 2.9 | 4.5 |
| Other | 164,781 | 192,640 | 80,939 | 82,188 | 87,987 | 181,999 | 68,541 | 100,017 | 128,329 |
| % total | 12.5 | 13.6 | 8.5 | 11.3 | 13.4 | 18.5 | 7.5 | 11.6 | 13.0 |

Source: UN Comtrade, <https://comtradeplus.un.org/TradeFlow> using SITC Rev 4 commodity code 731, machine tools removing metal.

Table 7. Russian imports of machining centres (units), 2013–21.

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021* |
|-------------|-------|-------|-------|-------------------|-------|-------|-------|-------|--------------------|
| Total | 2,200 | 5,354 | 1,878 | 1,350 | 1,553 | 1,544 | 2,486 | 1,260 | 1,290 ^a |
| Taiwan | 772 | 3,756 | 638 | 386 | 521 | 491 | 603 | 378 | n.d. |
| Japan | 121 | 173 | 173 | 167 | 90 | 98 | 271 | 41 | n.d. |
| Korea | 303 | 364 | 273 | 170 | 210 | 192 | 233 | 80 | n.d. |
| China | 153 | 127 | 96 | 168 | 253 | 281 | 152 | 305 | 667 |
| Subtotal | 1,349 | 4,420 | 1,180 | 891 | 1,074 | 1,062 | 1,259 | 804 | (667) |
| % total | 61.3 | 82.5 | 62.8 | 66.0 | 69.2 | 68.8 | 50.6 | 63.8 | 51.7 |
| Germany | 261 | 269 | 243 | 126 | 157 | 134 | 509 | 120 | 118 |
| USA | 293 | 271 | 170 | 122 | 159 | 141 | 50 | 116 | 9 |
| Switzerland | 47 | 102 | 91 | 32 | 30 | 67 | 146 | 7 | 13 |
| Italy | 32 | 42 | 48 | 19 | 26 | 28 | 270 | 20 | 59 |
| Czech Rep | 52 | 101 | 81 | 24 | 27 | 22 | 175 | 20 | 54 |
| Subtotal | 685 | 743 | 633 | 323 | 399 | 392 | 1,150 | 283 | 253 |
| % total | 31.1 | 13.9 | 31.7 | 23.9 | 25.7 | 25.4 | 46.3 | 22.5 | 19.6 |
| Other | 166 | 191 | 65 | 136 [†] | 80 | 90 | 77 | 173 | (370) |
| % total | 7.6 | 3.6 | 5.5 | 10.1 [‡] | 5.1 | 5.8 | 3.1 | 13.7 | 28.7 |

*No Russian import data for 2021 on UN Comtrade so exports to Russia. Note, no data for Korea; Japan and Taiwan reported by value but not quantity.

^aExcluding Poland reporting 9,538, clearly some form of small versatile machines perhaps for home/small scale use.

Source As Table 6.

the year, probably a much lower proportion by the end of the year. Türkiye, a country with a relatively modest machine tool industry supplying only \$2.2 million in 2021, entered the top three by value, presumably as a country willing to supply machines produced in countries that had stopped exporting to Russia directly, and the same probably applies to Estonia. Furthermore, Lithuania, Latvia, and Kazakhstan also each supplied \$2.4–3.2 million

Table 8. Top 10 exporters of metal cutting working machine tools to Russia in 2021 and 2022 by value (\$000).

| | 2021 | | | 2022 | |
|-------------|---------|-------|---------|---------|-------|
| | \$000 | % | | \$0000 | % |
| China | 238 041 | 31.8 | China | 441 893 | 56.5 |
| Germany | 163 387 | 21.8 | Taiwan | 105 355 | 13.5 |
| Taiwan | 95 848 | 12.8 | Türkiye | 51 964 | 6.6 |
| Italy | 62 587 | 8.3 | Korea | 44 920 | 5.7 |
| Czechia | 43 453 | 5.8 | Germany | 37 745 | 4.8 |
| Switzerland | 40 987 | 5.5 | Italy | 35 540 | 4.5 |
| Korea | 38 343 | 5.1 | Spain | 9 889 | 1.3 |
| Spain | 23 662 | 3.2 | Poland | 8 569 | 1.1 |
| Austria | 23 653 | 3.1 | Estonia | 6 910 | 0.9 |
| France | 19 678 | 2.6 | India | 6 664 | 0.8 |
| Total | 749 639 | 100.0 | | 782 584 | 100.0 |

Belarus, like Russia, failed to provide data to UN Comtrade.

Others of note in 2022, Czech Republic 5, Switzerland 4,566, Japan 3,957, USA 1,508, France 842.

Source As Table 6.

Table 9. Russia, imports of machine tools, top 10 countries by volume in unit terms, 2020–22.

| | 2020 | | 2021 | | 2022 | |
|---------|-------|-------|-------|-------|-------|-------|
| | | % | | % | | % |
| China | 1 581 | 42.2 | 2 049 | 44.8 | 4 454 | 64.8 |
| Taiwan | 830 | 22.1 | 920 | 20.1 | 1 242 | 18.1 |
| Korea | 377 | 10.1 | 643 | 14.1 | 638 | 9.3 |
| Germany | 348 | 9.3 | 414 | 9.0 | 148 | 2.2 |
| Italy | 119 | 3.2 | 229 | 5.0 | 48 | 0.7 |
| Japan | 134 | 3.6 | 129 | 2.8 | 85 | 1.2 |
| India | 34 | 0.9 | 58 | 1.3 | 84 | 1.2 |
| USA | 205 | 5.5 | 57 | 1.2 | 71 | 1.0 |
| Türkiye | 30 | 0.8 | 21 | 0.5 | 63 | 0.9 |
| Austria | 86 | 2.3 | 55 | 1.2 | 45 | 0.6 |
| Total | 3 744 | 100.0 | 4 575 | 100.0 | 6 878 | 100.0 |

Source. <https://pumori-invest.ru/o-kompanii/articles/novosti-kompanii/itogi-i-prognozy-v-sfere-metalloobrabotki-ekspertnyy-vzglyad/>The data appear to be those of the Russian customs service. While the customs service has stopped publishing data, it seems that specialist industry associations can still obtain them.

machines, almost certainly for the same reason. In 2022, the total number of machine tools imported appears to have increased to a quite significant extent. Overall, in 2022 sanctions probably had very limited impact on the overall supply of machine tools as Russia probably had stocks of uninstalled machines, not least at dealers acting on behalf of foreign companies who often held sizeable stocks to ensure quick delivery to customers and some equipment ordered before sanctions were imposed was delivered in the earlier part of the year. Above all, China increased its exports in both value and unit terms. Russian machine tool specialists often note that the quality of Chinese advanced machine tools is not yet up to the standards of leading Asian, European, and US suppliers, but that there has been a marked improvement in recent years. At the time of writing equivalent data for 2023 are not available.

The available evidence suggests an active search for new foreign partners since the start of the war. In May 2022 there was a large exhibition of Chinese machine tool builders and new partnership agreements emerged, in particular with the Lipetsk machine tool factory which now has the right to build Chinese machines

under its own 'LSP' brand name (ITO, 2022a). As noted above, 'STAN' is also engaged now in cooperation with Chinese partners. The Russian company 'Pumori-severo-zapad', previously focused on some Asian brands, has now become exclusive dealer of the Turkish company 'DNR', building NC lathes, milling machines, and surface grinders, and 'Pumori-inzhiniring', previously working with Japanese and European companies, has switched rapidly to cooperation with the leading, long-established, Indian machine tool company 'BFW', building a wide range of advanced, high-precision machines, including 5-axes machining centres (ITO, 2022b; Pumori-Invest, 2023; RITM, 2022). In Ekaterinburg, the company 'Ural Instrument Pumori' is selling deep hole drilling and reaming machines built by the Indian firm 'Precihole', a type of machine used to produce gun barrels and artillery systems (Ural Instrument Pumori, 2024).

Perhaps the most active drive to find a partner in a 'friendly' country is focused on Belarus, Russia's partner in the so-called Union State. In Soviet times Belarus possessed a strong, versatile, machine tool industry with some considerable strengths, not least in the production of machine tools for the motor industry. However, as in Russia the industry contracted to a considerable extent in the 1990s and its revival has been relatively recent. Unlike Russia most of the main enterprises remained in business together with some component suppliers and it proved possible to build most types of machine tools. However, the volume of production has been modest and simpler types have predominated. Thus in 2021 2,623 metal working machine tools were built, including 1,463 drilling machines, 309 grinding and other finishing machines, 238 lathes, only 39 of which were NC, 42 milling machines and only 28 machining centres (National Statistical Committee of the Republic of Belarus, 2023). The volume of production in 2022 is reported to have increased by almost 27% as the government of Belarus has sought to boost development (Gorbatenko, 2023).

At various times there have been initiatives to develop official links between the Russia and Belarus machine tool industries within the framework of the Union state. Thus in 2016 a joint engineering company 'SoyuzStankolnzhiniring' was created, approved by a joint meeting of the boards of the industrial ministries of the two countries. The Belarus founder was the holding company 'Belstankoinstrument' then included 16 enterprises and on the Russian side the 'STAN' group. The aim was to develop import substitution activities but little if anything appears to have been achieved (Rossiiskaya gazeta, 2023). More recently, in September 2022 the prime minister of Belarus Roman Golovchenko said that an inter-state machine tool-building cluster was to be formed, but this does not appear to have happened but Russian credit is now helping to fund at least two machine tool development projects in Belarus, the creation of multi-functional machining centres at 'StankoGomel' and of a range of gear cutting machines at 'BISTAN', Vitebsk (Gorbatenko, 2023; Sputnik, 2022). In July 2023, another attempt was made to promote cooperation with the signing of an agreement between the two governments to develop the machine tool and tooling industry. The signing took place at a joint session on the industry in Ekaterinburg at the international industrial exhibition 'INNOPROM', the Russian speaker being Boris Bogatyrev of 'STAN' and for Belarus the directors of two leading companies 'Stankozavod "Krasnyi Borets"' and 'StankoGomel'. Perhaps of significant potential given the strength of Belarus in the

production of integrated circuits, there was also discussion of cooperation in the sphere of NC systems, led by the commercial director of the Russian 'Mekhatronika' company (Institute Belorgstankinprom, 2023).

Not surprisingly, Russia has been able to obtain some machine tools manufactured by 'unfriendly countries' through parallel imports and covert means. Examples include claims by the Economic Security Council of Ukraine that at least 18 US Haas machine tools had been shipped to Russia between March and October 2022, but it was acknowledged that no 'smoking gun' was found that Haas had broken the law and the company vigorously denied the charge (Biasotti, 2023; Ostrovsky, 2023). Earlier there had been a report that some Russian defence industry enterprises had been supplied in 2018 with Swiss and German precision machine tools by a company based in Switzerland with links to 'Rostekh', a breach of sanctions imposed in 2014 (Informnapalm, 2023). In September 2023, the Ukrainian anti-corruption agency asked the German authorities to halt delivery of a 'Spinner' machining centre being sent to Russia from Turkey, its destination being a munitions plant in the Urals. The agency claimed that 'Spinner' machines were reaching Russia through a number of channels though the company firmly denied any knowledge (Nardelli & Krasnolutska, 2023; NAZK, 2023).

In November 2023, the United States imposed sanctions on a firm that had been supplying Russia with precision machine tools produced by the South Korean Hanwha company, putting an end to a trade that appears to have exploited loopholes in the sanctions regime (New U.S. sanctions halt South Korea's machine tool supply, 2023). In early 2024 another case arose involving a company in Russia well-known as a leading dealer in imported machine tools, iMachine Technology, established in 2011. This related to its reported supplying of Taiwanese machine tools to the Russian defence industry. In response, Taiwan's government imposed sanctions on iMachine, Moscow, and Taiwanese companies were forbidden to trade with the Moscow business. This measure has not been noted on iMachine's website, which advertises a wide range of machine tools, including models built by the Taiwanese company iMachine Tool Corporation. It has a large demonstration hall of machine tools, supplies spares for machines built by many companies and services machines it has supplied. Its website notes its close contacts with a number of Chinese machine tool producers (iMachine, 2024; Taiwan's government, 2024). But the reports of this kind on sanctions evasion since the start of the war suggest that the overall scale of acquisitions has not been large, although in some cases they may have accelerated the enlargement of capacities for the production of weapons.

Examination of volume of production and imports, plus the search for new partners suggests that the Russian defence industry, notwithstanding the imposition of sanctions, can still meet its needs for advanced machine tools to a quite significant extent from domestic sources of supply, supplemented by imports from a few non-sanctioning countries such as China. However, over time the defence sector may face problems maintaining its existing stock of imported advanced machines in operation as it will be difficult to obtain spare parts and service agreements with foreign companies or their agents in Russia will have ended. But prior to sanctions the network of foreign company agents in Russia employed many Russian personnel who presumably acquired the necessary skills and some components, if not all, may be obtainable by trade with 'friendly' countries and resort to parallel imports.

Conclusion

As of early 2024, the evidence indicates that Russia has managed to adapt with some success to the new situation, notwithstanding the imposition of tough sanctions intended to limit severely access to machine tools, especially those vital to the production of weapons. Domestic machine tool manufacture has been maintained, though not without some contraction in the building of some advanced types. Imports from sanctioning countries have fallen sharply but Russia has been active in seeking new sources of supply and has started to develop new partnerships with companies in 'friendly' countries. It is likely that the technological level and quality of some of the machines now being obtained from both domestic and foreign suppliers has fallen to some extent but this is probably regarded by engineering industry customers as an unavoidable short-term cost with expectations that there will be an improvement over time. This situation is not one that those imposing sanctions expected or desired so the question arises: how has Russian industry been able to adapt to the new situation?

It is doubtful that the machine tool industry would have adapted in the manner it has if it were not for the earlier sanctions of 2014. Prior to that some new actors had emerged, including defence industry companies, but the sanctions relating mainly to more advanced types of machines often used in military production focused the attention of the government on the need for action to promote import substitution and moderate the preference of Russian machine-building companies for imported production equipment based on a not always justified conviction that those built by domestic firms were likely to be of a backward technology and of low quality.

The companies involved in machine tool industry, especially some of those established during the last 10 to 15 year like 'STAN', 'PZMTs', and 'BPK' have shown enterprise and this does not appear to have diminished in cases when they have been absorbed into larger, state-dominated, structures as in the case of 'STAN' or, like 'PZMTs', have been spun off from large defence industry companies. This is a branch of small- to medium-sized companies with a market orientation and as such has responded in a predictable manner to government initiatives that have promoted its development. Thus the introduction of a 'product of Russia' certificate, notwithstanding some bureaucracy in its application, promoted import substitution and facilitated participation of machine tool companies in public procurement, in particular investment projects in the defence industry. It also boosted efforts to source key components in Russia such as spindle motors and NC systems. Over time, these measures helped in overcoming resistance on the part of Russian industrial companies to purchasing machine tools of domestic manufacture. In developing policy for the industry an active role has been played by the Association 'Stankoinstrument', which has maintained an active dialogue with both companies of the branch and government agencies.

The response of the Russian machine tool industry to sanctions has been very much in line with more general developments, as analysed by a group of researchers led by the Russian economist Andrei Yakovlev (Higher School of Economics, Moscow, and Harvard). Based on interviews with industrial company directors and other industry representatives, including some repeat ones in Jan–Feb 2023, they concluded that in the adaptation of Russian industry to the new conditions and number of key factors

emerged. Businesses learnt from previous experiences of negative developments and were prepared for the possibility that they might occur again. The majority of firms exhibited market behaviour, including state companies. Managers tended to see sanctions and external pressure on Russia as 'a professional challenge' requiring an adequate response on their part. The range of mechanisms of state support for businesses had evolved with new initiatives such as the Fund of Industrial Development and in the introduction of new measures industry has been involved in dialogue with government, including through industrial associations. For this reason the measures were often appropriate and taken up by companies. Finally, firms quickly undertook initiatives to switch the buying of components from their usual suppliers to countries willing to trade, such as China and Turkey (Yakovlev, 2023). In the case of the machine tool industry there has also been the important role of dealers of foreign machine tool companies with their networks, trained engineering personnel and knowledge of the sources of supply of key components. It would be interesting to know if this has been the case in other sectors of the engineering industry.

There are also parallels between the adaptation of the machine tool industry to the 'new situation', as Russian officials often term the post-February 2022 period, and that of the information and communications technology sector, as analysed in an informative report. Businesses were on the whole quick to adapt, though the speed of adaptation depended on the extent to which they had already accumulated stocks of imported components from countries that imposed sanctions. They sought alternative sources of supply both in Russia, where they sometimes found acceptable suppliers they had previously been unaware of, or in non-sanctioning countries, very often in China, Turkey, or countries of the Commonwealth of Independent States (CIS). Costs tended to rise and it often took longer to obtain the components needed but after a while new supply relations tended to settle down and become routine (Sprint, 2023).

Clearly war and the imposition of tough sanctions have had an impact on the Russian machine tool industry and the ability of the defence industry to obtain advanced machines. However, adaptation to the new conditions has been quite successful. At the time of writing, two years have elapsed since the war started and it is too early to draw final conclusions or to predict what the state of the industry will be like in the future. If the war were to end and sanctions were to be withdrawn, would machine tool companies quickly revert back to their former trade partners? This question must remain open. However, one point is clear: contrary to the claim cited in the Introduction, the available evidence shows that Russia is able to build advanced machine tools and there are no grounds for thinking that this capability will disappear.

Notes

1. See, for example, R. Amann, J.M Cooper, R. W.Davies, *The Technological Level of Soviet Industry* (1977), in particular Chapter 4, 'Machine tools'.
2. See Table 4 below.
3. Note, in Russia there is an official classification for the precision of machine tools: N (normal), P (raised precision), V (high precision), A (especially high precision) and S (special precision) (<http://ooo-asteko.ru/klassifikatsiya-metallorzhushchih-stankov-tablitsa/>). In the July 2023 measure, all machines have to be P, V, A or S.

4. On the alumni page of Stankin's website there is a prominent Mishustin citation, 'I know a very large number of absolutely wonderful financiers and economists who came out of not very good engineers, but I don't know even a single not very good engineer who came out of a good financier or economist' (Stankin, 2023),
5. See <https://stanki-chpu.ru/about>

Disclosure statement

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Appendix

Types of Machining Tools

There are many types of machining tools, and they may be used alone or in conjunction with other tools at various steps of the manufacturing process to achieve the intended part geometry. The major categories of machining tools are:

- **Boring tools:** These are typically used as finishing equipment to enlarge holes previously cut into the material.
- **Broaching tools:** A machining process that uses a toothed tool, called a broach, to remove material. There are two main types, linear, and rotary.
- **Cutting tools:** Devices such as saws and shears are typical examples of cutting implements. They are often used to cut material with predetermined dimensions, such as sheet metal, into a desired shape.
- **Drilling tools:** This category consists of two-edged rotating devices that create round holes parallel to the axis of rotation.
- **Grinding tools:** These instruments apply a rotating abrasive wheel to achieve a fine finish or to make light cuts on a workpiece.
- **Milling tools:** A milling tool employs a rotating cutting surface with several blades to create non-circular holes or cut unique designs out of the material.
- **Turning tools:** These tools rotate a workpiece on its axis while a cutting tool shapes it to form. Lathes are the most common type of turning equipment.

Machining centres: versatile machine tools than may combine functions listed above, e.g. turning, milling and grinding, shaping the workpiece along a number of axes.

Types of Burning Machining Technologies Welding and burning machine tools use heat to shape a workpiece. The most common types include: **Laser cutting:** A laser machine emits a narrow, high-energy beam of light that effectively melts, vaporises, or burns material. **Oxy-fuel cutting:** Also known as gas cutting, this machining method employs a mixture of fuel gases and oxygen to melt and cut away material. **Plasma cutting:** Plasma torches fire an electrical arc to transform inert gas into plasma of very elevated temperatures and is applied to the workpiece at high speed to melt away unwanted material.

Types of Erosion Machining Technologies Erosion machining devices use water or electricity to erode material off the workpiece. The two main types: **Water jet cutting:** This process uses a high-pressurised stream of water to cut through material. **Electric discharge machining (EDM):** Also known as spark machining, this process uses electric arcing discharges to create micro-craters that rapidly result in complete cuts, in applications requiring complex geometrical shapes in hard materials and at close tolerances.

- *NC/CNC Machining*

Numerical control (NC)/Computer numerical control machining (CNC machining) is a electronic control system or computer-aided technique that can be used in conjunction with a broad range of equipment. It requires software and programming to guide a machining tool in shaping the workpiece according to preset parameters. As opposed to manually guided methods, CNC machining is an automated process.

Precision Machining

Any machining process that requires unusually small cutting tolerances (between 0.013 mm and 0.0005 mm, as a rule of thumb) or very fine surface finishes may be considered a form of precision machining.

Source

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