BALTIC FORESTRY

http://www.balticforestry.mi.lt
ISSN 1392-1355
eISSN 2029-9230

Baltic Forestry 2022 28(2): 623
Category: Research article
https://doi.org/10.46490/BF623

The Russian forest industry: declining wood production and emerging opportunities in bioenergy

THOMAS THURNER [1]*, ILYA KUZMINOV [2] AND POLINA LOBANOVA [2]

[1] *Institute for Statistical Studies and Economics of Knowledge, Laboratory for Economics of Innovation, HSE University, 11 Myasnitskaya Str., Moscow, Russian Federation*
[2] *Institute for Statistical Studies and Economics of Knowledge, Centre for Strategic Analysis and Big Data, HSE University, 11 Myasnitskaya Str., Moscow, Russian Federation*

** Corresponding author: tthurner@hse.ru*

Thurner, Th., Kuzminov, I. and Lobanova, P. 2022. The Russian forest industry: declining wood production and emerging opportunities in bioenergy. *Baltic Forestry* 28(2): article id 623. https://doi.org/10.46490/BF623.

Received 29 November 2021 **Revised** 28 July 2022 **Accepted** 11 September 2022

Abstract

The aim of the study is to describe the main trends and possibilities in Russian forestry. Based on statistical data, the authors analyze general trends in the Russian forest industry like woodworking, roundwood and wood pellets production. Russia's output of roundwood, sawnwood, wood pellets, wood-based panels and veneer sheets has been growing steadily over the past 5 years. The production of only two wood-based panel types – hardboard and other fibreboard – is either absent or in decline. The results include decline in roundwood export and the growth rates in wood pellets, sawnwood, wood-based panels, and veneer sheets exports. The Russian forest industry has room to grow its export of forest products. This requires technology upgrading, which could be facilitated by proactive government policies.

Keywords: forest industry, woodworking industry, bioenergy, Russia

Introduction

Forests have great impact on the regulation of the hydrological cycle (Bartík et al. 2019), provide a diverse ecosystem and play a moderating role in the fight against climate change by capturing carbon (Bartík et al. 2019, Chugunkova 2019). This vital role that forests play in the support of life on earth is threatened by unsustainable methods of forestry, such as overexploitation, fragmentation and degradation, as well as the intentional burning of forests. Such activities have now become a matter of great concern (OECD iLibrary 2015). The most concentrated efforts of environmental conservation focus on the Amazonas Basin, also referred to as the 'green lung' of the world. There, illegal woodcutters convert – at a frightening speed – forests into grasslands for cattle (Yang 2018). Although the importance of the Amazonas rainforests for the world's climate and biodiversity cannot be overstated, it is Russia which hosts almost ⅕ of the world's forest area (39,958,245 km^3) and thereby the greatest wood reserves in the world (The World Bank 2021). Moreover, while the world's forest areas are decreasing, Russia's forests have been growing (Table 1). To maintain Russia's forest reserves in good condition, though, an efficient and economic operation of its forest industry is essential. In the past, however, the industry has been associated with outdated production methods and was struggling with low competitiveness, both in terms of value and quality of its products.

Recently, the situation of the Russian forest industry has attracted interest from scholars, such as Gordeev (2020) on general aspects of competitiveness, Chugunkova (2019) regarding the impact on climate change, Golovina and Dykusova (2020) on the financial aspects of 'green' projects in the Russian forest industry, and Pyzhev and Vaganov (2019) who call for reliable methods and a strong information base for estimating the carbon budget of Russian forests. All the above-mentioned contributions share the view that Russia's forest industry has great potential, but much remains unexplored and requires methodological appraisal. The very recent paper by Gordeev (2020) studied comparative advantages of different types of wood products and found the strongest comparative advantage in raw wood trade, but also identified improved positions in trade in semi-finished and finished wood products.

Methods

To analyze the situation of Russia's forest industry and to identify the main trends for its future development, the authors reverted to a statistical analysis based on published data from the Russian statistical yearbook, 2019 (RosStat 2019). We further enriched the analysis of individual industries such as woodworking, through official forestry data from the Food and Agriculture Organization of the UN (FAO 2020), including production quantity, export quantity and export value of the selected forestry items in Russia and in the world. The forestry products that attracted our interest included roundwood; wood pellets; sawnwood; wood-based panels including plywood, particle board, hardboard, HDF/MDF and OSB.

Based on the statistics from FAO (FAO 2020), we calculated:

1) the percentage of Russian exports of specific forestry production items in global trade;
2) the percentage of Russia's share in global production;
3) the export quantity of selected countries [1];
4) the export value of selected countries [1].

Results

Russia's forest industry – an overview

The total forested land area and size of Russia's timber resources has increased between 2010 and 2019 (Table 1).

The method of forest area estimation in Russia has been adjusted and relies now more on accurate remote sensing data, which explains the adjustment from 2010 to 2017.

Table 1. Russia's forest resources

(end of year)	2010	2017	2018	2019
Total area of forest lands, and lands of other categories with forests, mln. ha	1183.2	1184.5	1187.7	1187.6
forests, million ha	891.8	891.4	894.1	894.1
land used for forest industry, million ha	797.1	794.7	796.9	794.9
Total forest resources, bln. m^3	83.4	82.8	82.8	82.6

Data source: the Federal Agency for Forestry.

Forest dieback, a phenomenon that took root at the end of the Soviet Union and remained a concern until 2010, is no longer an issue (Table 2). The incidence of forests being destroyed by fires has also declined, while reforestation of burned forest plantations is eight times higher than in 2010. The land under reforestation is steadily increasing, while afforestation is declining in importance. The land under pest control is declining significantly, while the use of biological products dominates over chemical products

[1] Selected countries are all countries (except Russia) for which FAO resource has statistics. The same list of countries was described for all forestry products analyzed.

Table 2. Activities in afforestation

(end of year)	2000	2010	2017	2018	2019
Forest dieback *, thou. ha	777	805	218	223	169
of which from forest fires	710	626	109	100	105
Forest fires **, thou. ha	22.4	33.4	10.9	12.1	13.6
Burnt forest land **, thou. ha	1329	1962	3282	7408	8678
Burned forest plantations **, million ha	39.6	93.4	51.9	80.4	313.2
Reforestation *, thou. ha	973	812	962	940	1068
including creation of forest cultures	263	171	177	172	177
Afforestation *, thou. ha	29.9	7.9	3.5	10.0	11.1
Destruction or suppression of hazardous organisms by air means ***, thou. ha	-	-	1457.6	488.6	46.7
Destruction or suppression of hazardous organisms by land means, thou. ha:					
using chemical products	-	-	17.6	2.9	3.7
using biological products	-	-	12.8	24.6	38.8

Notes: * Since 2017 observation is being carried out, taking into account individual entrepreneurs; ** 2000 – based on RosStat data as of November 1, 2000; since 2010 – based on the Federal Agency for Forestry annual data; *** Air means imply the usage of aircraft to spray pesticides, etc. over forest lands in order to fights hazardous organisms.

(including spraying by air means). This is a sign of the increasingly efficient use of the country's forest resources.

An important feature of the Russian forestry giant organisations – which rank among the country's best performing entities by revenue (RBK Pro 2017–2019) – is their control over all stages of wood production, from harvesting to the distribution of final products (Matilainen 2010, 2013). Logging is the basic economic activity of the forest industry, which includes the harvesting of local raw timber and the transport from forests to processing facilities. Although the least value-adding economic activity, logging is most sensitive to changing market conditions.

Although the number of organisations active in logging is declining, the number of employees is rising (Table 3). Statistical data suggests that major market players in the industry acquire a larger share in it leaving less space for smaller companies in forestry. This is an indicator for a consolidation phase long overdue since the end of the Soviet Union. Consolidation also indicates that the forestry market in Russia is maturing. The downward trend of profitability in the logging sector relates to declining market prices (RosStat 2019). A possible future reduction in output due to the declining profitability is imposing a risk on subsequent industries, such as timber and pulp and paper production.

Investments in Russia's forest industry have been steadily increasing for the past years (Table 4). In 2014 investments in fixed assets amounted to near 140 billion roubles, while in 2018 – already 176 billion roubles (Panytin 2020). This fact has signalled rising business opportunities,

Table 3. Main indicators of logging

	2017	2018	2019
Organisations (end of year)*, thou.	8.0	7.6	6.9
Average annual number of employees in organisations, thou. persons	70.6	85.0	84.7
Balanced financial result (profits)**, million roubles	–231	295	–1075
Profitability of goods (works, services) sold, percent	5.5	7.6	2.3

Notes: * According to data obtained from RosStat (RosStat 2019); ** According to data taken from accounting reports; since 2019 – according to data obtained from the state information resource for accounting statements (operated by the Federal Tax Service of Russia) (RosStat 2019); the (–) sign indicates loss.

Table 4. Investments in Russian forest industry

	2014	2015	2016	2017	2018
Investments, billion roubles	139.6	138.9	147.5	160.2	175.9
Investments, billion USD*	2.66	2.65	2.8	3.1	3.4

Note: * At the exchange rate on 30.06.2022.

mainly related to export markets. Other factors supporting the competitiveness of Russia's forest industry include cheap electricity and labour, and the availability of ample water resources (Antonova and Lomakina 2020).

Roundwood and sawnwood

Russia's share of roundwood production in the world did not change and in 2019 maintained the level of 2015, but the quantity rose slightly (Figure 1). By global comparison, Russia ranks among the five leading producers of roundwood, together with the USA, China, Brazil and Canada.

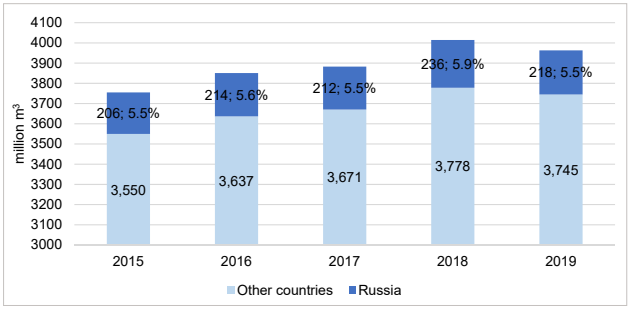

Figure 1. Roundwood production in Russia and other countries, million m³ and % of total world production (FAO 2020)

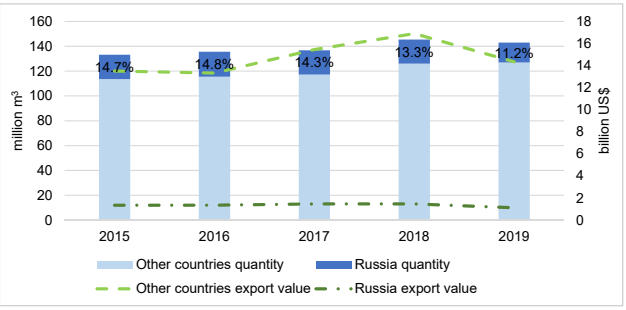

Figure 2. Roundwood: export value, quantity, and % of world export quantity (FAO 2020)

Russia's export quantity and value of roundwood is continuously declining (Figure 2). Although Russia has historically dominated the global market for roundwood, and its exports rose steadily until 2006, the Government of the Russian Federation increased export tariffs for roundwood by a Decree of the President dated July 1, 2007 (Turner 2008). Moreover, in the next few years and until now tariffs continued to rise. In 2007, the increase consisted from 6.5% to 20%, in 2009 – to 25%, in 2019 – to 40% and in 2020 – to 60%.

Illegal logging remains one of the most serious problems related to forest industry in Russia. According to statistics (Stoilova 2021), in 2017 it consisted of 1.7 million m³, in 2018 – 1.1 million m³, in the first and second quarters of 2019 – 0.6 million m³. The scale of illegal timber harvesting and trade, including the export of roundwood to European countries under the guise of processed products, explains the policy interference which became necessary as previous control measures to limit the overuse of Russia's forests were circumvented by shadow schemes.

Besides, the governmental decision to hinder the roundwood exports is connected to the necessity to develop Russia's own wood processing industry. Some research has shown that it positively impacts the speed of pulp and sawnwood industry progress (Bykanova 2018).

Sawnwood, on the other hand, saw its export quantity and value increasing, and Russia is continuously expanding its share of global exports (Figure 3). The global sawnwood production expanded from 2015 to 2018 from 449 million to 491 million m³ (Figure 4). Russia's share of the global production of sawnwood is steadily increasing,

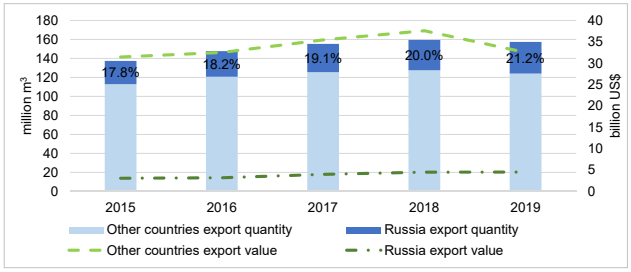

Figure 3. Sawnwood: export value, quantity, and % of world export quantity (FAO 2020)

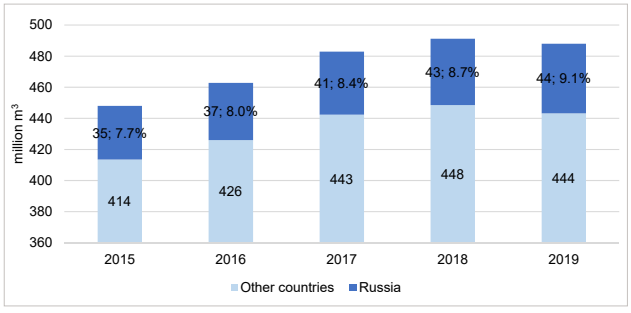

Figure 4. Sawnwood production in Russia and other countries, million m³ and % of total world production (FAO 2020)

reaching 9.1% in 2019. World trade grew in line with production and reached nearly 160 million m³ by 2018. China's production increased by 32% and reached 90 million m³ (FAO 2019), as the country became the largest importer of both sawnwood and roundwood. Russia produced 43 million m³ of sawnwood in 2018 and became the largest exporter of sawnwood in the same year, followed by Canada, Germany, Sweden and Finland. The country's exports exceed 24 million m³ (Russian Timber Industry 2018).

Wood pellets and other agglomerates

Forest bioenergy, which describes biomass used for energy production, is obtained from residuals, generated by the manufacture of wood products, and end-of-life wood products. Biomass is used for household cooking and heating; it also has industrial applications for heat, steam and electricity production (Walsh 2004). Especially the forest industry residues gathered from logging and the removal of cull (trees which are not suitable for further processing; for instance, rotten trees, with numerous limbs or splits), dead and dying material have attracted interest as they are an abundant renewable resource with reduced greenhouse gas emissions compared to fossil fuel systems. Long seen as low-value by-products, the fast-rising demand for renewable energy production is changing the value relation among forest product categories. Though there are some challenges regarding the quality of bioenergy production, such as possible moisture and impurities, harmful impact or accessibility issues because of the logging season which is limited in time, etc., there are still many advantages regarding biomass usage. For instance, bioenergy production to a lesser degree depends on the quality of forest resources. For example, low-quality roundwood is now also used for energy production (Cowie et al. 2019). There are other examples of the benefits of bioenergy production: it is accessible because of sufficient resources, and in line with modern trends biomass does not produce carbon emissions. This is a significant advantage for Russia, as the technological level of its forest industry ranks below that of its competitors.

From the end of 2000 onwards, Russia became an important producer and exporter of wood pellets and other agglomerates. At the same time, however, pellets were also increasingly used as energy supply in internal production processes of local industries, which thereby increased their energy efficiency and reduced reliance on grid energy. The global production of wood pellets and other agglomerates is on the rise and reached almost 44 million tonnes in 2018. In that year, Russia produced 2.5 million tonnes of wood pellets and other agglomerates and occupied the 5th place among the major suppliers (Table 5). The leading producer was the United States with an output of more than 6 million tonnes. Global trade in wood pellets and other agglomerates also continues to rise. From 2017 to 2018, the traded volume increased by 17% to 27 million tonnes. In 2019, Russia continued to increase the export of its wood pellets and other agglomerates by 70% in comparison to 2015 (Figure 5). The export value also increased from 2015 to 2019. Russia's internal demand is likely to increase, too, as bioenergy has so far played a rather insignificant role in the country's own energy mix. Estimations propose that as little as 12% of Russia's total potential in bioenergy is currently used. Bioenergy could in the future account for up to 30% of all domestic electricity consumption (Namsaraev et al. 2018). Although Russia's underdeveloped bioenergy was already identified by earlier publications (e.g. Hoogwijk et al. 2005), the rising global demand for bioenergy is now offering new opportunities. Demand from both within Russia and its export markets are likely to increase further.

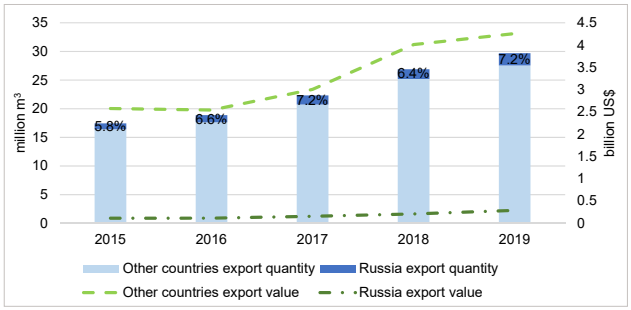

Figure 5. Wood pellets and other agglomerates: export value, quantity, and % of world export quantity (FAO 2020)

Wood-based panels

The global production of wood-based panels grew from 345 million m³ in 2015 to 370 million m³ in 2019 (Figure 6). The Asia-Pacific countries produced 61%, or 248 million m³, with China's production alone accounting for 50% of the global volume. Significant output growth happened in Russia, where production rose from 14 to 16 million m³. Since 2015, the country's exports of wood-based panels have increased from 4 million m³ to 6.2 million m³. Global export has also grown since 2015 until 2018, while export declined in 2019 compared to 2018 both in quantity and value (Figure 7).

Table 5. Wood pellets and other agglomerates (million tonnes) production (FAO 2020)

Product	2015		2016		2017		2018		2019	
	Russia	Other countries	Russia	Other countries	Russia	Other countries	Russia	Other countries	Russia	Other countries
Wood pellets and other agglomerates	1.6	31.2	1.9	33	2.3	36.8	2.5	41.4	3.3	45.5

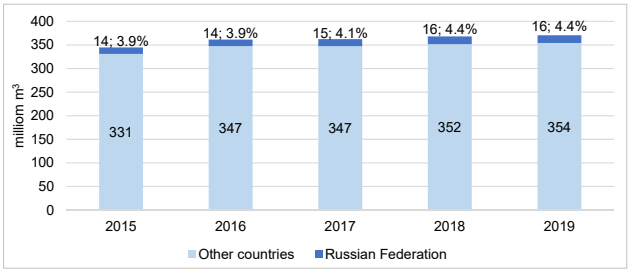

Figure 6. Wood-based panels production: million m³, and % of world production quantity (FAO 2020)

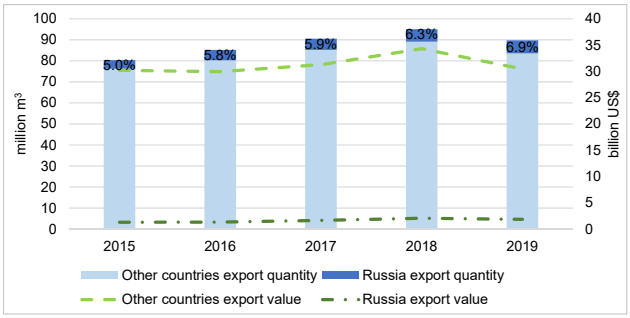

Figure 7. Wood-based panels: export value, quantity, and % of world export quantity (FAO 2020)

Veneer sheets

Veneer sheets out of Russia accounted for ⅒ of global production by 2019. During the past few years, Russia increased its export of veneer sheets, and its share in global trade reached almost 15% (Figure 8). While global production has been steadily growing during the considered period (Figure 9), global trade increased in value, not quantity.

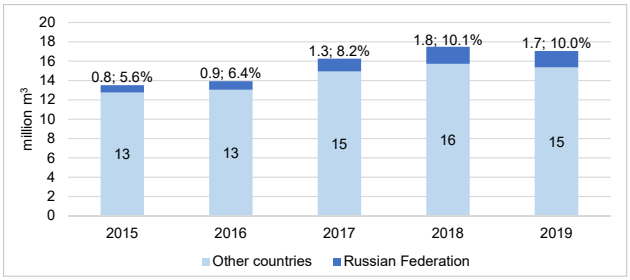

Figure 8. Veneer sheets production: million m³, and % of world production quantity (FAO 2020)

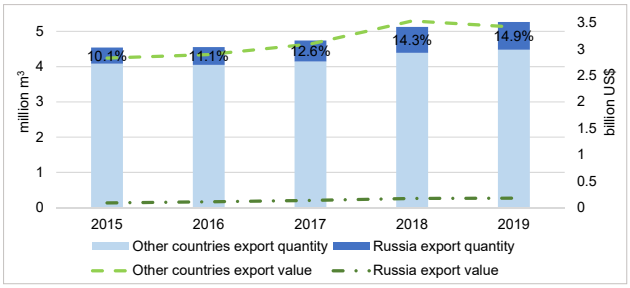

Figure 9. Veneer sheets export: export value, quantity, and % of world export quantity (FAO 2020)

Plywood

Wood-based panels are type of wooden products that, according to the FAOSTAT classification, include plywood, particle board, hardboard, MDF/HDF, OSB and another fiberboard. Plywood production is a mass timber product that requires an elevated degree of processing capabilities. It remains one of the most rapidly growing and investment-attractive sectors of the forest industry. Consequently, Russia's output in plywood almost doubled over the past decade (Figure 10). The industry benefits greatly from the availability of low-priced raw materials. The figures show that the export quantity and value of plywood in Russia increased from 2015 to 2019 (Figure 11).

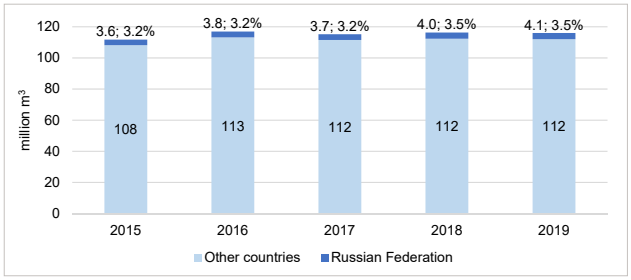

Figure 10. Plywood production: million m³, and % of world production quantity (FAO 2020)

Figure 11. Plywood export: export value, quantity, and % of world export quantity (FAO 2020)

Particle board, hardboard, MDF/HDF and OSB

The particle board production in Russia has remained relatively stable for quite some time now, while global production is growing. Since 2015, output has increased from 6.6 to 7.2 million m³ (Figure 12). Export indicators demonstrate general growth for Russia and other countries both in value and quantity (Figure 13). Since 2015, the global hardboard production slowly declined from 8.7 to nearly 6.5 million m³ by 2019. Both the export quantity and value show quite low results. Russia's export quantity has not changed much, while other countries' share of global trade has slightly increased. MDF/HDF production showed steady growth throughout the analyzed period. In countries other than Russia, the amount of MDF/HDF production increased from 99 to 102 million m³. At the same

time, Russia's share in total world output increased from 2.2% to 3.1%, the production quantity increased 1,5 times. The export indicators have not changed significantly since 2015 globally, though Russia raised its export both in quantity and value. Since 2015, Russia gradually extended the scope of OSB manufacturing to 4% of the world production. It must be acknowledged that the global OSB production demonstrated notable growth during this period as well. Russian OSB export is on the rise, though its share of global trade is minimal (2.5%).

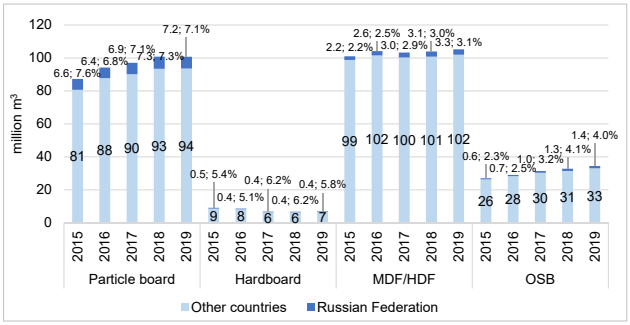

Figure 12. Particle board, hardboard, MDF/HDF and OSB production: million m³, and % of world production quantity (FAO 2020)

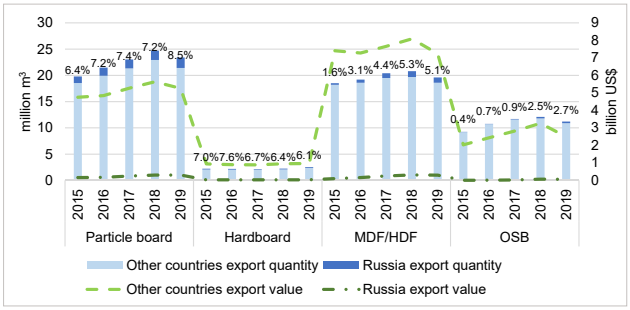

Figure 13. Particle board, hardboard, MDF/HDF and OSB export: export value, quantity, and % of world export quantity (FAO 2020)

Findings

The currently used technology base remains an issue. On the one hand, most technical innovations target the replacement of wooden fibres with non-wooden fibres, the alternative uses of residuals and the reduction of waste production. On the other hand, many biocomposites of the industry now find use in construction materials, for instance, due to their excellent mechanical properties, such as their resistance to acid and alkali and corrosion in general (Zhang et al. 2019). Still, the production processes are based on the infrastructure of the USSR, and technological innovation and new management approaches are rare. The total number of forestry enterprises that reported technological innovations was high during 2015–2017 (Gokhberg 2017, Gorodnikova et al. 2019), which suggests an improvement of production facilities. The innovations, though, gradually develop and target catching up with state-of-the art technologies from outside Russia. Not a single Russian company transferred new technologies to industry players beyond Russia. The demand for technological solutions will also emerge from the need to counter global warming. Increasing losses from forest fires and shorter winter felling seasons impose a significant risk on the industry (Goltsev and Lopatin 2013, Chugunkova and Pyzhev 2020).

Discussion and conclusions

The Russian Forest Industry is in a process of change. Its structure and dominant strategies that had remained in use since the end of the Soviet Union are being replaced by a stronger orientation towards export markets; and while the number of organisations is shrinking, employment is on the rise. A similar trend has been observed in Russia's agriculture (Gokhberg 2017, Thurner and Zaichenko 2018, Bakhtin et al. 2020). Russia's output of roundwood, sawnwood, wood pellets, wood-based panels and veneer sheets has been growing steadily over the past 5 years. The production of only two wood-based panel types – hardboard and other fibreboard – is either absent or in decline.

At the same time, the achieved growth rates of the export of wood pellets have still been lagging other countries' averages. There is room for growth through market share expansion in these highly promising markets. Russia's export statistics reflect the politically imposed decline in exports of roundwood to stimulate high value-added exports and improve the wood processing industry of the country. Higher roundwood export tariffs did, indeed, result in a rise in the export of processed goods. In general, there are vast opportunities for further growth for the share of exports of Russia's forest products. Russia's sawnwood production has benefited from China's demand for construction material. Also, energy production from biomass could potentially have a bright future, with a fast-increasing demand from well-capitalised markets in Europe. To benefit from the global trends, a viable strategy seems to be an intensive development model (as opposed to extensive growth) based on technological upgrading.

Acknowledgements

The article is based on the study funded by the Basic Research Program of the HSE University.

References

Antonova, N.E. and Lomakina, N.V. 2020. Institutional Innovations for the Development of the East of Russia: Effects of Implementation in the Resource Region. *Journal of Siberian Federal University. Humanities and Social Sciences* 13(4): 442–452. https://doi.org/10.17516/1997-1370-0580.

Bartík, M., Holko, L., Jančo, M., Škvarenina, J., Danko, M. and Kostka, Z. 2019. Influence of Mountain Spruce Forest Dieback on Snow Accumulation and Melt. *Journal of Hydrology and Hydromechanics* 67(1): 59–69. https://doi.org/10.2478/johh-20,8-0022b.

Bykanova, O.A., Akhmadeev, R.G., Glubokova, N.Y. and Kravchuk, I.S. 2018. The global market of roundwood: Financial aspects. *Bulgarian Journal of Agricultural Science* 24(1): 8–16.

Chugunkova, A.V. and Pyzhev, A.I. 2020. Impacts of global climate change on duration of logging season in Siberian boreal forests. *Forests* 11(7): 756. https://doi.org/10.3390/f11070756.

Chugunkova, A.V. 2019. Napravleniia adaptatsii i smiagcheniia posledstvii izmeneniia klimata dlia ekonomiki lesnogo khoziaistva Rossii [Climate change mitigation and adaptation options in the Russian forestry sector]. *Ekonomicheskii analiz: teoriia i praktika [Economic analysis: theory and practice*] 18(11): 2078–2102 (in Russian with English abstract). https://doi.org/10.24891/ea.18.11.2078.

Cowie, A.L., Brandão, M. and Soimakallio, S. 2019. Quantifying the climate effects of forest-based bioenergy. In: Letcher, T.M. (Ed.) Managing Global Warming: an Interface of Technology and Human Issues. London: Academic Press, p. 399–418. https://doi.org/10.1016/B978-0-12-814104-5.00013-2.

FAO. 2019. Global Forest Products. Facts and Figures 2018. Rome: Food and Agricultural Organization of the United Nations, 18 pp. Available online at: http://www.fao.org/3/ca7415en/ca7415en.pdf (accessed: 30 June 2022).

FAO. 2020. FAOSTAT. Forestry Production and Trade. Available online at: http://www.fao.org/faostat/en/#data/FO/visualize (accessed: 30 June 2022).

Gokhberg, L.M. (Ed.) 2017. Prognoz nauchno-tekhnologicheskogo razvitiia agropromyshlennogo kompleksa Rossiiskoi Federatsii na period do 2030 goda [Expected research and technology development of agro-industrial complex of the Russian Federation for the period until 2030]. The Ministry of Agriculture of Russia; National Research University 'The Higher School of Economics' (NIU VShA). Moscow: NIU VShA Press, 140 pp. (in Russian).

Golovina, E.Y. and Dykusova, A.G. 2020. Financing of Innovative Projects in the Forest Industry. *IOP Conference Series: Earth and Environmental Science* 459(5): 062030. https://doi.org/10.1088/1755-1315/459/6/062030.

Goltsev, V. and Lopatin, E. 2013. The impact of climate change on the technical accessibility of forests in the Tikhvin District of the Leningrad Region of Russia. *International Journal of Forest Engineering* 24(2): 148–160. https://doi.org/10.1080/19132220.2013.792150.

Gordeev, R. 2020. Comparative advantages of Russian forest products on the global market. *Forest Policy and Economics* 119: 1–12. https://doi.org/10.1016/j.forpol.2020.102286.

Gorodnikova, N., Gokhberg, L., Ditkovskiy, K., Kuznetsova, I., Lukinova, E., Martynova, S., Ratai, T., Rosovetskaya, L., Fridlyanova, S. 2018. Indikatory innovatsionnoi deiatelnosti: 2018: statisticheskii sbornik [Indicators of Innovation in the Russian Federation: 2018: Data Book]. Moscow: National Research University 'Higher School of Economics' (HSE), 344 pp. (in Russian).

Hoogwijk, M., Faaij, A., Eickhout, B., De Vries, B. and Turkenburg, W. 2005. Potential of biomass energy out to 2100, for four IPCC SRES land-use scenarios. *Biomass and Bioenergy* 29(4): 225–257. https://doi.org/10.1016/j.biombioe.2005.05.002.

Matilainen, A.M. 2013. Forest companies, corporate social responsibility, and company stakeholders in the Russian forest sector. *Forest Policy and Economics* 31: 44–49. https://doi.org/10.1016/j.forpol.2011.12.006.

Matilainen, A.M. 2010. Holding companies and business integration in the Russian forest industry sector. In: Huttunen, T. and Ylikangas, M. (Eds.) Witnessing Change in Contemporary Russia. Helsinki: WS Bookwell, Kikimora Publications Series B 38, p. 284–306.

Namsaraev, Z.B., Gotovtsev, P.M., Komova, A.V. and Vasilov, R.G. 2018. Current status and potential of bioenergy in the Russian Federation. *Renewable and Sustainable Energy Reviews* 81: 625–634. https://doi.org/10.1016/j.rser.2017.08.045.

OECD iLibrary. 2015. OECD Environment Statistics (database). Forest Resources. https://doi.org/10.1787/data-00600-en (accessed 30 June 2022).

Panytin, A., Tereshchenko, S., Polyanskaya, O., Shaitarova, O. and Mushkarova, O. 2020. Investment attractiveness of the forest sector in Russian Federation. *IOP Conference Series: Earth and Environmental Science* 574(1): 012059. (V Pan-Russian Scientific-Technical Conference-Webinar "Forests of Russia: Policy, Industry, Science and Education", 16–18 June 2020, Saint Petersburg, Russian Federation). Available online at: https://iopscience.iop.org/article/10.1088/1755-1315/574/1/012059#references.

Pyzhev, A.I. and Vaganov, E.A. 2019. Rol rossiiskikh lesov v realizatsii Parizhskogo klimaticheskogo soglasheniia: vozmozhnosti ili riski? [Global Climate Change Economics: The Role of Russian Forests]. *ECO* 11: 27–44 (in Russian with English abstract). https://doi.org/10.30680/ECO0131-7652-2019-11-27-44.

RBK Pro. 2022. RBK 500. RBK Pro predstavliaiet reiting krupneishikh po vyruchke kompanii Rossii [RBC 500. RBC Pro presents the rating of the largest companies in Russia by revenue, 2021]. Available online at: https://pro.rbc.ru/rbc500 (accessed 30 June 2022).

RosStat. 2019. Rossiyskiy statisticheskiy yezhegodnik. 2019: Statisticheskii sbornik [Russian Statistical Yearbook 2019: Statistical Handbook]. Moscow: Federal State Statistics Service, 708 pp. Available online at: https://rosstat.gov.ru/storage/mediabank/Ejegodnik_2019.pdf (accessed 30 June 2022).

Russian Timber Industry. 2018. Sawmilling. Available online at: https://programlesprom.ru/en/napravleniya/sawmilling/ (accessed 30 June 2022).

Stoilova, A.S. 2021. Impact of the Prospective Roundwood Export Ban on Russian Timber Production. *Journal of Siberian Federal University. Humanities and Social Sciences* 14(7): 1080–1091. https://doi.org/10.17516/1997–1370–0786.

The Federal Agency for Forestry. Available online at: http://www.rosleshoz.gov.ru/ (accessed 30 June 2022).

The World Bank. 2020. Data. Forest area (% of land area). Available online at: https://data.worldbank.org/indicator/AG.LND.FRST.ZS (accessed 30 June 2022).

Turner, J.A., Buongiorno, J., Katz, A. and Zhu, S. 2008. Implications of the Russian roundwood export tax for the Russian and global wood products sectors. *Scandinavian Journal of Forest Research* 23(2): 154–166. https://doi.org/10.1080/02827580801995307.

USDA. 2016. Forest Inventory and Analysis Glossary. Available online at: https://www.nrs.fs.fed.us/fia/data-tools/state-reports/glossary/ (accessed 30 June 2022).

Walsh, M.E. 2004. Biomass resource assessment. In: Cleveland, C.J. and Ayres, R.U. (Eds.) Encyclopaedia of Energy. Amsterdam: Elsevier Academic Press, Vol. 1 (Encyclopaedia of Energy Series), p. 237–249.

Yang, Y. 2018. Amazonian Deforestation: A panel approach. P. 4–34.

Zhang, Q., Li, Y., Cai, H., Lin, X., Yi, W. and Zhang, J. 2019. Properties comparison of high-density polyethylene composites filled with three kinds of shell fibers. *Results in Physics* 12: 1542–1546. https://doi.org/10.1016/j.rinp.2018.09.054.