BOFIT Policy Brief
2020 No. 11

Heli Simola

Climate change and the Russian economy

Bank of Finland, BOFIT
Institute for Economies in Transition

BOFIT Policy Brief
Editor-in-Chief Mikko Mäkinen

BOFIT Policy Brief 11/2020
1.9.2020

Heli Simola
Climate change and the Russian economy

ISSN 2342-205X (online)

Bank of Finland
BOFIT – Institute for Economies in Transition

PO Box 160
FIN-00101 Helsinki

Phone: +358 9 183 2268

Email: bofit@bof.fi
Website: www.bofit.fi/en

Contents

Heli Simola

Climate change and the Russian economy

Abstract

Even with substantial uncertainty over the timing and magnitude of climate change, the potential impacts pose significant risks to long-term global economic development. This paper reviews relevant literature on economic effects of climate change with respect to Russia, which faces physical risks as well as risks created by the transition to a low-carbon economy. Most risks arise from the orientation of Russian production and exports to carbon-intensive sectors, particularly oil and gas. Nevertheless, Russia has shown little ambition in addressing risks related to climate change.

Keywords: Russia, economy, climate change

1. Introduction

While climate change is widely regarded as a serious risk, the Russian government and Russian society have long been sceptical towards climate change in general, and especially the contribution of human activity to climate change. Russia often treats climate change as a subset of issues within the spheres of foreign or security policy. Awareness and recognition of climate-related risks have increased in recent years, but climate issues still garner low policy priority. Russia only gave official acceptance to the Paris agreement in October 2019, making it one of the last of the major carbon-emitter countries to do so (Kokorin & Korppoo, 2017; Makarov et al., 2018; Paramonova, 2020; Tynkkynen, 2019).

Russia introduced its first national climate doctrine in 2009. The accompanying and complementing policy documents that followed were fairly general and aspirational in nature. They set forth an overall framework for climate policy, but lacked specific measures or details on practical implementation. Climate issues and their associated risks also have been included in various policy doctrines (e.g. security) over the past decade. In spring 2020, the Ministry of Economic Development presented a draft version of "The strategy of the long-term development of the Russian Federation with low level of GHG emissions until 2050" (hereafter, Low emission strategy 2050).The strategy aligns with Russia’s modest national targets under the Paris agreement.

Risks related to climate change have received more attention in Russia’s financial sector. The Bank of Russia (BoR), for example, joined the recently established international cooperation group, the Network of Central Banks and Supervisors for Greening the Financial System (NGFS). The BoR wants to stimulate public debate on climate issues through publications that discuss climate risks to the financial sector and aspects related to green financing (BoR, 2019 and 2020).

In this paper, we present a brief overview on the literature related to the economic effects of climate change,[1] specifically focusing on the economic effects for Russia. We also discuss the risks posed by climate change to Russia’s economic development and Russia's preparedness to respond to challenges related to climate change. The paper is structured as follows. Section 2 summarizes some of the main aspects of climate change globally and in Russia. Section 3 reviews the literature on economic effects of climate change. Section 4 discusses possibilities of the Russian economy to adjust for climate risks. Section 5 concludes.

2. Climate change and Russia

Very simply put, climate change in the current discussion typically refers to rise of the average global temperature and various environmental phenomena viewed to follow from this warming, like rising sea levels and increased frequency of extreme weather events. The IPCC (2018) estimates that global average temperature has increased by about 1 °C since pre-industrial times. The average global temperature is presently estimated to be increasing by about 0.2 °C per decade. In Russia, warming is much faster than the global rate, i.e. an estimated average of 0.45 °C per decade and 0.8 °C per decade in the Arctic region (Roshydromet, 2017).

The dominant cause of the rise in temperature has likely been the increased concentration of greenhouse gas (GHG) emissions arising from human activities (IPCC 2018). As atmospheric concentrations of GHGs rise, global temperatures rise. Although researchers have yet to specify the exact severity or time horizon for emission accumulation, concentrations of GHGs and other

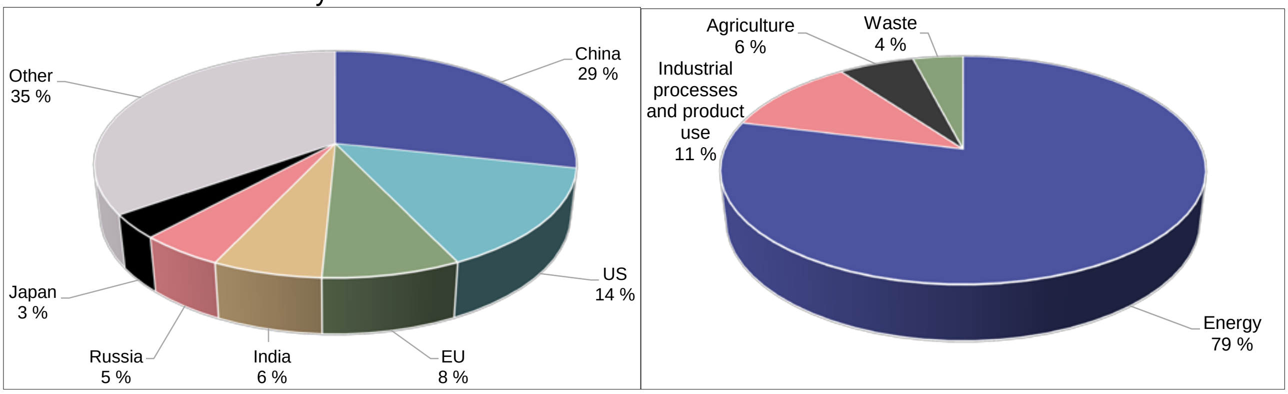
[1] We focus only on economic effects, although climate change can have much wider severe consequences e.g. on human health and mortality.

pollutants could eventually surpass a tipping point with irreversible consequences. CO_2, in particular, accumulates in the atmosphere and accounts for the largest share of GHG emissions arising from human activities.[2] As the means for removing CO_2 from the atmosphere are limited, the only way to avoid reaching this critical limit is to reduce emissions caused by human activity to zero.

Without mitigation measures, the IPCC foresees the increase in carbon emissions will raise the average global temperature by 3–4 °C compared to pre-industrial times by the end of this century. To avoid reaching a tipping point, climate experts want to constrain the increase in average global temperatures to a level 1.5–2 °C above the pre-industrial baseline. Most countries committed to this target in the framework of the 2015 Paris agreement. The IPCC says that mankind will have to attain zero net carbon emissions globally by around 2070 to stay within the 2 °C limit. Any delays in emission cuts imply sharper and deeper cuts later as that deadline approaches (ESBR, 2016).

Russia is a top CO_2 emitter both in absolute and per capita terms. Russia accounts for about 5 % of global emissions (Figure 1, panel A). As elsewhere, Russia's GHG emissions are mainly caused by energy use (Figure 1, panel B). Half of energy-related emissions in Russia originate from energy-producing industries, 15 % from transport and 10 % from manufacturing and construction activity. Within the manufacturing sector, the metal and chemical branches account for the largest shares of emissions.

Figure 1. Panel A: The distribution of global CO_2 emissions by country in 2014. Panel B: The distribution of Russia's GHG emissions by sector in 2017.



Sources: Worldbank, UNFCCC.

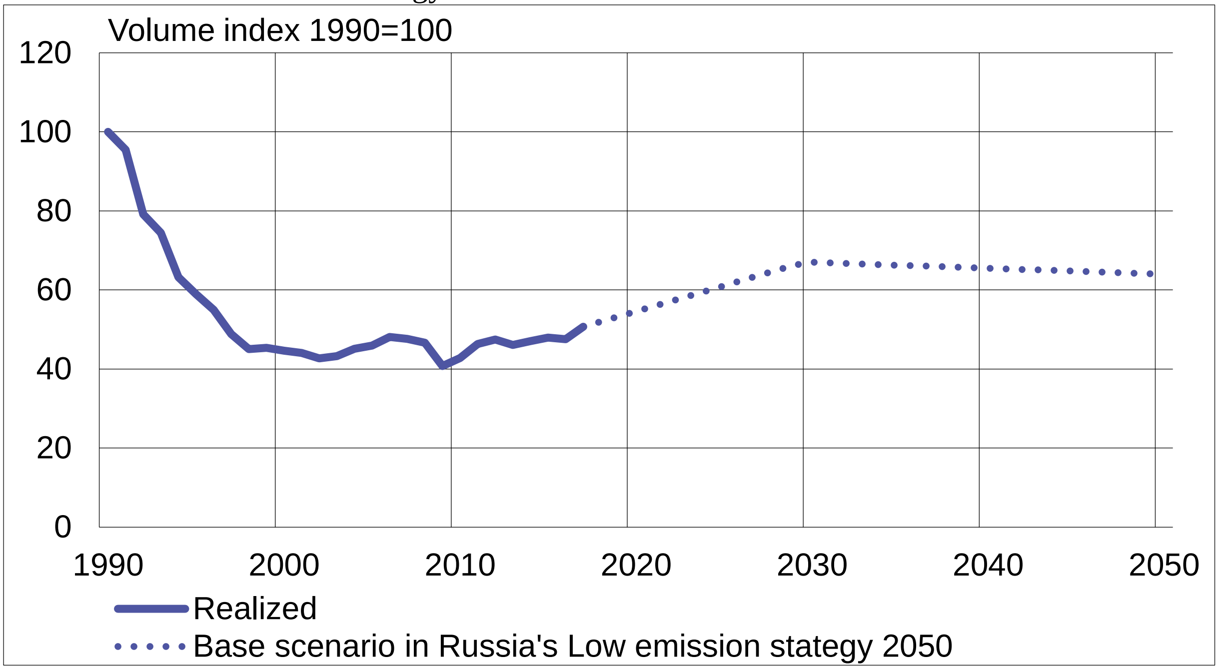
The substantial decline in Russian GHG emissions in the 1990s reflects a massive contraction in output and economic restructuring that occurred in the wake of the Soviet Union's collapse. Emissions have increased slightly in recent years, but still are only about half of the level of 1990,[3] the base year for contributions laid down in the Paris agreement for Russia and most other countries. Russia gave formal acceptance to the Paris agreement last year and targets restricting its GHG emissions in 2030 to 70–75 % of the level of 1990. Indeed, Russia's Low emission strategy 2050 allows for emissions to *rise* throughout the upcoming decade (Figure 2).[4]

[2] For simplicity's sake, the discussion here concentrates on CO_2 emissions, recognizing, of course, the relative contributions of all greenhouse gases. According to the UNFCCC, CO_2 emissions accounted for 76 % of Russia's total GHG emissions in 2017.

[3] Including land use, land use change and the forestry sector (LULUCF); without LULUCF the level is about two-thirds the 1990 level. For more discussion on the role of LULUCF in the case of Russia, see e.g. Kokorin & Korppoo (2017).

[4] Nationally Determined Contributions (NDCs) under the Paris agreement vary across countries. For example, China's targets call for peak CO_2 emissions by 2030 and a decline thereafter. The US initially aimed at a reduction of 26–28 % of GHG emissions by 2025 compared to 2005 level, but has decided to withdraw from the Paris agreement effective in November 2020. The EU initially committed to cut GHG emissions by 2030 by at least 40 % compared to the 1990 level.

Figure 2. Russia's GHG emissions (incl. LULUCF) and the expected trend under the base scenario of Russia's Low emission strategy 2050.



Sources: UNFCC, Russia's Ministry of Economic Development.

3. Economic effects of climate change

The potential economic effects related to climate change can be divided into physical and transitory risks. *Physical risks* arise from the climate-related hazards that affect human systems. Physical risks extend from extreme weather events such as hurricanes to gradual effects from global warming. *Transitory risks* arise from a society's shift to a low-carbon economy. Policy measures to curb carbon emissions are a key source of these risks (Batten et al., 2016).

3.1 Physical risks: Extreme weather events

Climate change has been linked to an increase in the frequency and severity of extreme weather events and natural disasters such as windstorms and floods. For an economy, extreme weather events can cause negative supply shocks by destroying crops, buildings and infrastructure. Negative demand shocks can also arise through diminished household wealth or damage to the physical and financial assets of companies that reduces consumption and business investment. On the other hand, reconstruction efforts after a severe weather event can create a positive demand shock (Batten et al., 2020).

The empirical literature on economic effects of extreme weather events and natural disasters implies that on average they have a negative short-run effect on economic growth due to loss of productive capacity. The empirical evidence on longer-run effects is somewhat scarce and mixed, but a few studies imply that the negative effects can be persistent. Negative effects are more pronounced for developing countries, which apparently reflects an ability of developed economies to cushion

In 2020, the EU submitted to the UNFCCC its long-term strategy that includes a further target of zero net GHG emissions by 2050.

disaster impacts with public-sector support measures (Batten et al., 2018; Cavallo & Noy, 2010; Dell et al., 2014).

Extreme weather events affect agriculture in particular. Most studies find that weather shocks have adverse and often quantitatively substantial effects on agricultural output (Dell et al., 2012; Lesk et al., 2016). Crop destruction due to extreme weather events may even cause an increase in global food prices. Although there seems to be considerable heterogeneity as to the inflation impacts of natural disasters, the effects are likely significant at least in developing economies (Parker, 2016; Heinen et al., 2018).

Extreme weather events also pose risks to the financial sector. Global weather-related disasters generated a record USD 320 billion in economic damage in 2017. Insurance companies face distress from increased claims due to the higher frequency and severity of extreme weather events. Uninsured losses due to natural disasters may reduce the value of collateral such as real property used to secure loans. A negative economic shock can raise the amount of non-performing bank loans. (Andersson et al., 2020; Batten et al., 2016; Bolton et al., 2020; NGFS, 2019)

As elsewhere, Russia has experienced an increase in the severity and frequency of extreme weather events in recent decades (Roshydromet, 2017). During the 2010s, for example, the total costs of severe extreme weather events are estimated to total around USD 7 billion, with the largest losses arising from wildfires, droughts, heat waves and flooding (EM-DAT, 2020). The heatwaves and droughts in 2010 and 2012 cut Russia's grain production substantially and pushed up cereal prices on global markets (Batten et al., 2020; Safonov & Safonova, 2013).

3.2 Physical risks: Gradual changes

The main long-term physical risk related to climate change is global warming[5]. Higher temperatures can affect the productive capacity of an economy through various channels. A hotter climate can reduce the productivity of natural capital (e.g. agricultural production) and labor. It can also require adaptive investment (e.g. in air conditioning) that reduces the pool of resources available for investment in productive capital and productivity-improving research and development (Batten et al., 2020).

The findings from the literature on global warming suggest that an increase in the average temperature tends to have a negative effect on the economy (Dell et al., 2014). The effect seems to be non-linear with the threshold evaluated at around 15 °C (Burke et al., 2015; IMF, 2017). If the average annual temperature of a region exceeds 15 °C, an increase in the average temperature has a negative effect on the economy.

In quantitative terms, recent surveys show that the roughly 40 estimates considered most relevant suggest that a 3 °C increase in the global average temperature leads to 2–10 % lower level of global GDP compared to a baseline with no global warming (Howard & Sterner, 2017; Nordhaus & Moffat, 2017; Tol, 2018). Burke et al. (2015), notably, evaluate the loss at about 20 % from the baseline. Most climate scenarios, however, suggest that it will take six or seven decades to reach this magnitude of warming assuming no mitigation measures are taken.

With the exception of a handful of regions in southern Russia, the average annual temperature in Russian regions is well below the 15 °C threshold. Therefore, studies that report estimates for Russia separately tend to find that at least a moderate increase in the average annual temperature would have a slightly *positive* effect on Russian economy (Burke et al., 2015; IMF, 2017; Kahn et al., 2019; Leppänen et al., 2017; OECD, 2015; Roson & Sartori, 2016). The positive effect reflects e.g. reduced space-heating costs and increased possibilities for agricultural production. Certain

[5] We focus only on global warming as research on economic effects of other gradual changes is scarce and results tend to be vague (Dell et al. 2014).

models factor in higher inward tourism flows due to more favourable climatic conditions. If global warming continues without any mitigation measures, however, this could lead to a roughly 10 % drop GDP per capita in Russia by 2100 compared to the trajectory with temperature stabilization (Kahn et al., 2019).

The uncertainty related to these estimates is extremely high, especially with respect to longer time horizons and larger temperature rises. The standard modeling approach for economic effects of global warming (Integrated Assessment Models or IAMs) has been strongly criticized. For other models, it is uncertain as to how well historical short-term weather variations are applicable in forecasting long-term warming trends. (Batten et al., 2018; Dell et al., 2014; Pindyck, 2017)

There is also much uncertainty related to estimates for Russia, especially as all effects cannot be taken into account in standard modeling frameworks. A key example of this in the case of Russia is melting of the permafrost layer, which covers over half of Russian territory (Roshydromet, 2017). Permafrost melting can cause substantial damage to buildings, roads, pipelines and other critical infrastructure in the northern parts of the country, and can impede production and transport of oil and gas which are largely located in Russia's permafrost areas.

3.3 Transition risks

Transition risks refer to effects arising from the shift to a low-carbon economy. A key source of transition risks are policies implemented to achieve the reduction. Mechanically, there are three ways to reduce carbon emissions: reduce production, reduce energy intensity of production or reduce carbon intensity of energy production (Batten et al., 2018). As the latter two alternatives are less costly in economic terms, so governments tend to adopt policies that concentrate on improving overall energy efficiency and reducing the use of carbon-intensive energy sources such as coal and oil.

From an economic perspective, carbon emissions are a negative externality. The social costs associated with carbon-intensive products are much higher than the nominal price paid by producers and consumers. A key policy objective is to price carbon emissions in a way that reflects the long-term costs to society. The most widely proposed economically optimal policy solution is the carbon tax. In practice, however, it is extremely difficult to estimate the appropriate level of the tax, i.e. the social cost of carbon (SCC). Estimates vary hugely across models and even within models as assumptions change (Auffhammer, 2018; Nordhaus, 2018; Pindyck, 2017).

Despite the difficulties related to the optimal tax design, several countries and regions have developed policy measures for pricing carbon, e.g. the EU's emission trade system (ETS). There are also several other (primarily fiscal) policy measures geared to climate change mitigation. These include subsidies and credit guarantees to support low-carbon investment, direct public spending on e.g. infrastructure that supports the shift to a low- carbon economy and regulation restricting use of carbon and carbon-intensive products (Andersson et al., 2020; Krogstrup & Oman, 2019; Pigato, 2019).

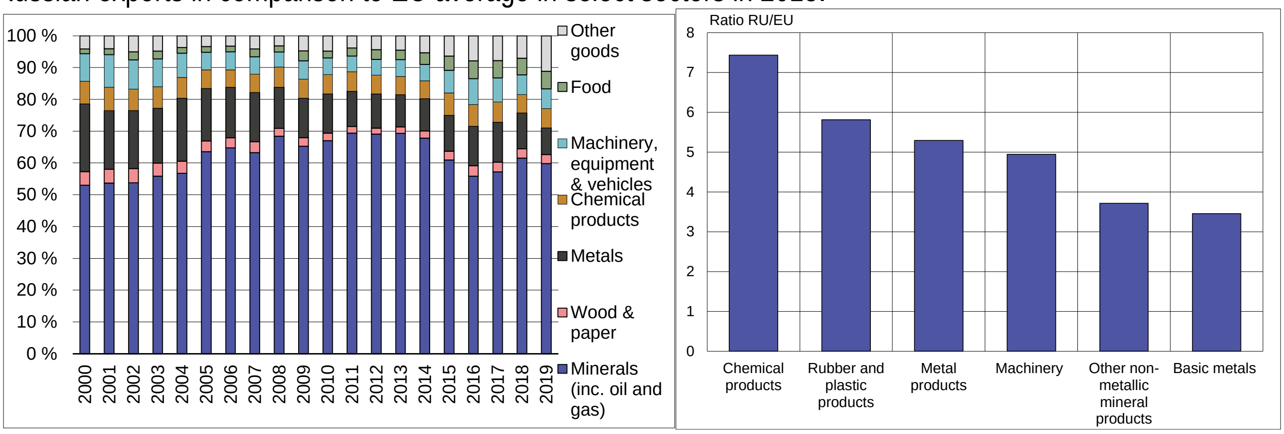
Transition risks are important to financial markets as the transition to a low-carbon economy would imply that many carbon-intensive assets become stranded or obsolete. The estimates on the global value of stranded assets typically vary between USD 1 to 4 trillion, and Russia is among the countries subject to the largest losses in terms of stranded asset values. If transition risks are not currently fully taken into account in the financial markets, their realization could sharply impact the market value of oil and gas companies, as well as other companies involved in carbon-intensive production. Negative effects could spill over further to the financial sector through corporate debt markets. Uncertainty related to the quantitative estimates is very high in this case, and market assessments are rather vague on valuation of assets at risk of becoming stranded (Andersson et al., 2020; Bolton et al., 2020; Mercure et al., 2018).

Regarding Russia, transition risks related to domestic policies seem quite modest for the near term. As noted above, Russia's targets on curbing carbon emissions are unambitious and allow for emissions to rise at least through the end of this decade. Although legislation is under preparation, CO_2 emissions remain unregulated by the state. Introduction of a carbon-pricing scheme is not on the agenda, but has been mentioned in the Low emission strategy 2050 (Mitrova et al., 2020).

Transition risks arising for Russia from climate policies of other countries are more significant. If most countries pursue their Paris agreement commitments, demand for carbon-intensive products will decrease. As illustrated by the discussion within the EU on potential border-adjustment measures for carbon, many countries are planning tighter carbon pricing policies. This could hamper Russian exports significantly, especially as the EU is a key export market for Russia (Mitrova et al., 2020; Simola, 2020).

Russian exports are heavily focused on energy and other carbon-intensive sectors. Carbon-intensive products such as mineral fuels, metals and wood account for about 80 % of Russian goods exports – and there has been little change in their composition over the past two decades (Figure 3, panel A). In 2018, the value of these exports was USD 360 billion (22 % of GDP). The literature also suggests little progress in diversification, complexity or quality improvements in Russian exports over recent decades (Gylfason, 2018; Lyubimov, 2019; Worldbank, 2019). The average carbon intensity of Russian exports is many times higher in all industrial sectors compared to the EU average (Figure 3, panel B).

Figure 3. Panel A: Product structure of Russian goods exports in 2000–2019. Panel B: Carbon intensity of Russian exports in comparison to EU average in select sectors in 2015.



Sources: CEIC, OECD.

Due to its export structure and technological deficiencies, Russia is among the top countries in the world in terms of carbon intensity of exports (Makarov & Sokolova, 2014). This situation may further erode the already poor competitiveness of Russian goods, especially in EU markets. One recent estimate claims that the export losses resulting from other countries fulfilling their Paris agreement targets could reduce Russian GDP growth by 0.2–0.5 % annually through 2050 (Makarov et al., 2018). The negative effects would hit certain regions heavily focused on production of raw materials such as coal particularly hard (Piskulova et al., 2013; Makarov et al., 2018).

Transition risks have potentially substantial implications for Russia's financial markets as carbon-intensive companies account for a significant share of Russia's corporate sector. According to the latest rating by the Russian journal *Expert*, oil, gas and coal companies accounted for a third of the combined net sales of Russia's 400 largest companies in 2018, while metallurgical companies accounted for an additional share of almost 10 %. The weight of oil & gas sector companies In Moscow stock exchange broad market equity index is nearly half, and the weight of metal and mining companies close to 20 %. Russia's ten largest exporters are companies involved in oil, gas, coal or metals.

The Russian banking sector has a large exposure to carbon-intensive sectors. Although the most carbon-intensive sectors account for 35 % (about 13 trillion rubles) of the total corporate loan stock,[6] the potential indirect risks could be even more severe. Risks also extend to public sector finances as the state has substantial stakes in the largest Russian oil and gas companies. Tax and tariff income from oil & gas production and exports account for over 20 % of total public sector income in Russia.

4. Russia's adjustment possibilities

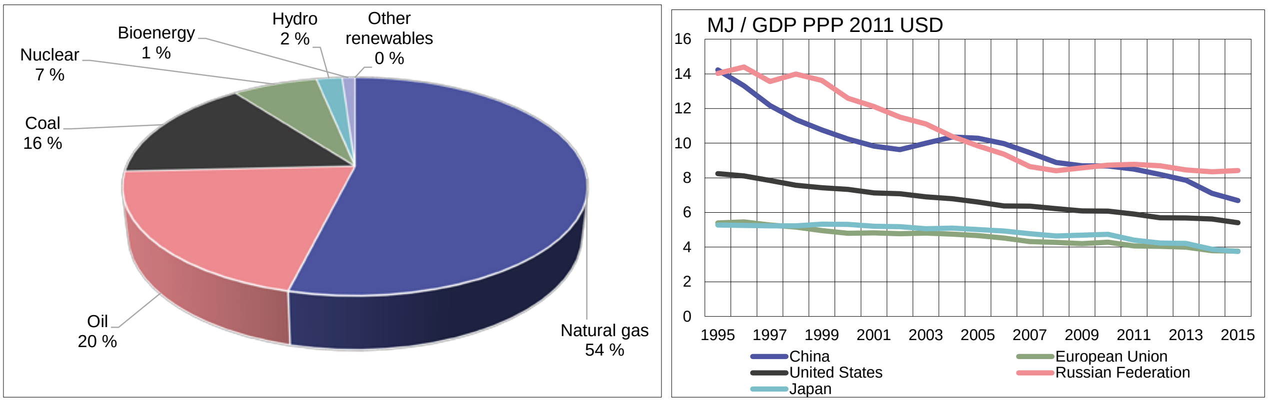
Regardless of Russia's preferences, global developments in climate policy could force Russia to give higher priority to climate issues. If other countries choose to shift to a low-carbon economy, Russia must follow at least to some extent. A gradual transition process leaves more time for adjustment, but long delays could lead to sudden or sharp policy changes with substantial adverse effects on carbon-intensive sectors, especially production of hydrocarbons (ESRB, 2016). While progress so far has been sluggish, Russia has potential to adjust through reducing carbon intensity in its energy sector, reducing energy intensity of production and diversification of its economy.

4.1 Energy supply and energy efficiency

Combustion of hydrocarbons meets roughly 90 % of Russia's primary energy demand (Figure 4, panel A). Natural gas, which has lower emissions than other hydrocarbon fuels, provides the bulk of this energy. Oil is mainly used by the transport sector and coal for power generation and by certain industries. Hydropower, bioenergy and other renewable energy sources account for about 3 % of primary energy consumption. No major changes in the Russian energy mix are planned in the next decade-and-a-half according to the recently approved energy strategy up to 2035. The strategy sees only a slight increase in renewable energy sources. In principle, there is huge potential for renewable energy production and even exports in Russia, but the costs are still much higher compared to traditional energy sources (IRENA, 2017; Potashnikov et al., 2018).

6 The figures refer to end-March 2020. Carbon-intensive sectors include mining and quarrying, manufacturing of coke and petroleum products, manufacturing of paper and paper products, manufacturing of chemical products, manufacturing of other non-metallic minerals, manufacturing of metals and metal products, agriculture, electricity, gas and water supply, and transport and communications. The Russian figures may be slightly biased upwards due to the lack of more disaggregated data. For comparison, the share of carbon-intensive sectors in the assets of the Dutch banking sector was 11 % in 2016 (DNB, 2017) and in the corporate loan stock of the Finnish banking sector 19 % as of end-June 2019 (Ala-Kiuttu & Tiililä, 2019).

Figure 4. Panel A: Russia's primary energy consumption in 2018. Panel B: Energy intensity trends in select countries from 1995 to 2015.



Source: IEA.

Regarding energy efficiency, the energy intensity of Russian GDP (amount of energy needed to produce one unit of output) has almost halved since mid-1990s (Figure 4, panel B). Still, energy intensity is nearly the highest among middle- and high-income countries. The energy intensity of Russia's most important products is 1.5 to 4 times higher than that of best-practice countries (MoE, 2020). There is much potential for energy-efficiency improvement in Russia, especially in its industrial and residential sectors (IRENA, 2017). Improving energy efficiency of power generation, industrial production and buildings is mentioned in Russia's Low emission strategy 2050 as the main means of restricting carbon emissions in the next decades. In 2018, investment in energy saving and energy efficiency amounted to a mere 0.2 % of GDP (MoED, 2020). Some large Russian corporates have, at their own initiative, devised climate strategies and plans for emission reduction to retain their positions in international markets (Mitrova et al., 2020; Paramonova, 2020).

4.2 Diversification

Diversification of Russia's economic structure away from hydrocarbons has been a long-standing goal of Russian economic policy as a means of reducing exposure to commodity price swings. Russia's current national development goals for 2030 also include a target for increasing non-energy exports. Again, as noted above, success of diversification policies has been modest to date.

Diversification is not an easy task for any country and there is no textbook solution suitable for all countries. In the Russian case, the failure of diversification is often related to the unwillingness or incapability of officials to push through reforms that support or promote other production. Motivation for shifting away from hydrocarbon production is reduced by potential detrimental effects on employment in the short-term and increase in domestic energy costs (Mitrova et al., 2020).

Russian industrial policy is criticized for ineffective measures like emphasizing import-substitution and mismanagement (Djankov, 2015; Lyubimov, 2019; Volchkova & Turdyeva, 2016). The strong political influence of hydrocarbon sector companies could also hinder diversification efforts (Tynkkynen, 2019). Moreover, the government does not consider diversification a pressing issue (Djankov, 2015; Kokorin & Korppoo, 2017). In recent decades, oil prices have generally been high enough to ensure acceptable development of economy, allowing the government to treat the global transition away from hydrocarbon energy sources as a concern for the distant future.

To illustrate this last point, we compare the scenarios on the development of global hydrocarbon demand in the latest IEA World Energy Outlook to the expectations on export demand trends in Russia's energy strategy to 2035. The expectations differ substantially, with Russia's energy strategy anticipating generally much stronger growth (Table 1).[7] Note specifically that the IEA sustainable development scenario is aligned with Paris agreement targets. It foresees a large decline in demand for all major hydrocarbon fuels except natural gas. Moreover, growth in natural gas demand growth occurs mainly in Asia. Shifting gas deliveries to Asia would require additional investment from Russia. Russia's current export capabilities to Asian markets are limited. Judging just from the view taken in Russia's energy strategy, it seems that the government is unprepared to deal with major shifts in global energy demand.

Table 1. Comparison of growth scenarios for global hydrocarbon demand in IEA WEO 2019 and growth scenarios of Russian hydrocarbon exports in Russia's energy strategy to 2035.

Volume change in 2018–2035, %	IEA WEO 2019 Global demand		Russia's energy strategy 2035 Russian export volume	
	Stated policies	Sustainable development	High case	Low case
Crude oil	8.8	-21.8	-3.3	-6.5
Gasoline	-0.8	-36.6	373.8	326.2
Diesel	9.7	-24.3	80.8	52.9
Natural gas	27.3	2.0	97.8	46.8
Coal	-0.2	-49.0	86.4	22.2

Note: IEA Sustainable development figures are extrapolated to 2035 linearly from the reported figures for 2030 and 2040.

5. Conclusion

Despite substantial uncertainty on the timing and magnitude of potential impacts from climate change, there are considerable risks to global development and Russia's economic development specifically over the longer horizon. Climate experts appeal to governments to take decisive preventive measures to deal with global warming in the near term to avoid reaching a potential tipping point with irreversible consequences. They note that delaying measures today may force even more abrupt and unpleasant policy changes later, making adjustment more difficult.

Climate issues have never had high priority in the Russian policy agenda. The consequences of climate change are often considered modest and applicable to a few regions. Indeed, the current literature suggests that Russia is among the countries that are less exposed to direct economic consequences from physical risks related to climate change, but these results are subject to considerable uncertainty. Regardless of Russia's own interpretation of the situation, its economy is highly vulnerable to the risks posed by the transition to a low-carbon economy. Implementation of ambitious climate policies in other countries could substantially reduce demand for Russian exports and hamper the availability of foreign financing for Russian companies.

Russia's economy has traditionally rested upon high energy intensity, and renewables still play a minor role in the energy mix. Russian exports largely involve carbon-intensive sectors, especially oil, and the average carbon intensity of all exports is high due to antiquated production technologies. Russia has possibilities to adjust to the potential global shift towards a low-carbon economy and climate issues lately have received more attention in policy discussions. Previous development strategies also mention diversification of the economy as an important goal, but progress has been modest. This issue is getting more pressing, however, as the vulnerabilities of the Russian economy to climate change become more apparent.

[7] Russian energy strategy to 2035 predicts the volume of crude oil exports to decline, but only because it assumes that more crude oil will be refined domestically to make higher-value petroleum products for export.

References

Ala-Kiuttu, A. and Tiililä, N. (2019). The Finnish financial system has strong links to emission intensive sectors (in Finnish). Bank of Finland Analysis, October 2019. https://www.bofbulletin.fi/fi/2019/artikkelit/paastointensiivisilla-toimialoilla-vahvat-kytkokset-suomen-rahoitusjarjestelmaan/

Andersson, M., Baccianti, C. and Morgan, J. (2020). Climate change and the macro economy. ECB Occasional Paper No. 243, June 2020.

Auffhammer, M. (2018). Quantifying economic damages from climate change. Journal of Economic Perspectives, 32(4), 33-52.

Bank of Russia (2020). Impact of climate risks and sustainable development of the financial sector of Russian Federation (in Russian). Paper for public consultation, Moscow, May 2020. https://www.cbr.ru/Content/Document/File/108263/Consultation_Paper_200608.pdf

Bank of Russia (2019). Concept of organizing in Russia a methodological base for developing green finance instruments and sustainable investment projects (in Russian). Expert council on long-term investment market, Moscow 2019. https://cbr.ru/Content/Document/File/84163/press_04102019.pdf

Batten, S. (2018). Climate change and the macro-economy: a critical review. Bank of England Staff Working Paper No. 706, January 2018.

Batten, S., Sowerbutts, R. and Tanaka, M. (2020). Climate change: Macroeconomic impact and implications for monetary policy. In Walker, T., Gramlich, D., Bitar, M. and Fardnia, P. (eds.), Ecological, Societal and Technological Risks and the Financial Sector, Palgrave Studies in Sustainable Business in Association with Future Earth.

Batten, S., Sowerbutts, R. and Tanaka, M. (2016). Let's talk about the weather: the impact of climate change on central banks. Bank of England Staff Working Paper No. 603, May 2016.

Bolton, P., Despres, M., Pereira da Silva, L.A., Samama, F. and Svartzman, R. (2020). The green swan: Central banking and financial stability in the age of climate change. Bank of International Settlements, January 2020.

Burke, M., Hsiang, S.M. and Miguel, E. (2015). Global non-linear effect of temperature on economic production.

Cavallo, E. and Noy, I. (2010). The economics of natural disasters: A survey. IDB Working Paper 124, May 2010.

Dell, M., Jones, B.F. and Olken, B.A. (2014). What do we learn from the weather? The new climate-economy literature. Journal of Economic Literature, 52(3), 740-798.

Dell, M., Jones, B.F. and Olken, B.A. (2012). Temperature shocks and economic growth: Evidence from the last half century. American Economic Journal: Macroeconomics, 4(3), 66-95.

Djankov, S. (2015). Why Russia has failed to diversify exports? PIIE Trade and Investment Policy Watch, September 2015. https://www.piie.com/blogs/trade-investment-policy-watch/why-has-russia-failed-diversify-exports

De Nederlandsche Bank (2017). Waterproof? An exploration of climate-related risks for the Dutch banking sector. https://www.dnb.nl/en/binaries/Waterproof_tcm47-363851.pdf

EM-DAT (2020). The International Disaster Database, Center for Research on the Epidemiology of Disasters. https://www.emdat.be/

European Systemic Risk Board (2016). Too late, too sudden: Transition to a low-carbon economy and systemic risk. Reports of the Advisory Scientific Committee No. 6, February 2016.

Gylfason, T. (2018). From economic diversification to growth. In Arezki, R., Boucekkine, R., Frankel, J., Laksaci, M. and van der Ploeg, R. (eds.), Rethinking macroeconomics of resource-rich countries. VoxEU eBook, CEPR Press, April 2018.

Heinen, A., Khadan, J. and Strobl, E. (2018). The price impact of extreme weather in developing countries, Economic Journal, 129 (619), 1327-42.

Howard, P.H. and Sterner, T. (2017). Few and not so far between: A meta-analysis of climate damage estimates. Environmental Resource Economics, 68, 197-225.

IMF (2017). The effects of weather shocks on economic activity: How can low-income countries cope? World Economic Outlook 2017.

IPCC (2018). Global warming of 1.5 °C, an IPCC special report. https://www.ipcc.ch/sr15/

IRENA (2017). REmap 2030 Renewable Energy Prospects for Russian Federation, Working Paper, International Rewable Energy Agency, Abu Dhabi.

Kahn, M.E., Mohaddes, K., Ng, R.N.C., Pesaran, M.H., Raissi, M. and Yang, J.C. (2019). Long-term macroeconomic effects of climate change: A cross-country analysis. NBER Working Paper 26167, August 2019.

Kokorin, and Korppoo, A. (2017). Russia's ostrich approach to climate change and the Paris agreement. CEPS Policy Insight 2017/40, November 2017.

Kolstad, C. and Moore, F.C. (2019). Estimating the economic impacts of climate change using weather observations. NBER Working Paper 25537, February 2019.

Krogstrup, S. and Oman, W. (2019). Macroeconomic and financial policies for climate change mitigation: A review of the literature. Danmarks Nationalbank Working Paper No. 140, September 2019.

Leppänen, S., Solanko, L. and Kosonen, R. (2017). The impact of climate change on regional government expenditures: Evidence from Russia. Environmental and Resource Economics, 67, 67-92.

Lesk, C., Rowhani, P. and Ramankutty, N. (2016). Influence of extreme weather disasters on global crop production. Nature, 529, 84-87.

Lyubimov, I. (2019). Russia's diversification prospects. Russian Journal of Economics, 5(2), 177-198.

Makarov, I.A., Chen, H. and Paltsev, S.V. (2018). Impacts of Paris Agreement on Russian economy (in Russian). Voprosy Ekonomiki, 4(2018), 76-94.

Makarov, I. and Sokolova, A. (2014). Carbon emissions embodied in Russia's trade (in Russian). Ekonomicheskii Zhurnal VSE, 3(2014), 477-507.

Mercure, J.F., Pollitt, H., Vinuales, J.E., Edwards, N.R., Holden, P.B., Chewpreecha, U., Salas, P., Sognnaes, I., Lam, A. and Knobloch, F. (2018). Macroeconomic impact of stranded fossil fuel assets. Nature Climate Change, 8(7), 588-593.

Ministry of Economic Development of Russia (2020). Long-term development strategy of Russian Federation until 2050 with low level of greenhouse gas emissions (in Russian).

Ministry of Energy of Russia (2020). Energy Strategy of Russian Federation until 2035 (in Russian).

Mitrova, T., Khokhlov, A., Melnikov, Yu., Perdereau, A., Melnikova, M. and Zalyubovsky, E. (2020). Global climatic threat and Russian economy: Searching for *the* way. Skolkovo Energy Center, May 2020.

Network for Greening the Financial System (2019). A call for action. Climate change as a source of financial risk, April 2019. https://www.ngfs.net/en/first-comprehensive-report-call-action

Nordhaus, W.D. and Moffat, A. (2017). A survey of global impacts of climate change: Replication, survey methods and a statistical analysis. NBER Working Paper 23646.

OECD (2015). The economic consequences of climate change. OECD Publishing, Paris.

Paramonova, Natalia (2020). Will EU Green Deal force Russia to clean up its act? Carnegie.ru Commentary, July 2020. https://carnegie.ru/commentary/82275

Parker, M. (2016). The impact of disasters on inflation. ECB Working Paper No. 1982, November 2016.

Pigato, M.A., ed. (2019). Fiscal policies for development and climate action. World Bank Group, Washington D.C.

Pindyck, R.S. (2017). The use and misuse of models for climate policy. Review of Environmental Economics and Policy, 11(1), 100-114.

Piskulova, N.A., Kostyunina, G.M. and Abramova, A.V. (2013). Climate policies of Russia's main trading partners and their impact on exports of several Russian regions (in Russian). WWF, Moscow 2013.

Potashnikov, V., Lugovoj, O. and Loginova, A. (2018). Role of renewable energy sources in fulfilling the INDC targets and in scenarios of low carbon development (in Russian). Nauchny Vestnik IEP 12(2018), 43-49.

Roshydromet (2017). Report on climate risks on the territory of the Russian Federation (in Russian). Russian Federal Service for Hydrometeorology and Environmental Monitoring, St. Petersburg, 2017.

Roson, R. and Sartori, M. (2017). Estimation of climate change damage functions for 140 regions in the GTAP9 database. Journal of Global Economic Analysis, 1(2016), 2, 78-115.

Safonov, G. and Safonova, Y. (2013). Economic analysis of the impact of climate change on agriculture in Russia. Oxfam Research Reports, April 2013.

Simola, H. (2020). CO_2 emissions embodied in EU-China trade and carbon border tax. BOFIT Policy Brief 4/2020.

Tol, R.S.J. (2018). The economic impacts of climate change. Review of Environmental Economics and Policy, 12(1), 4-25.

Tynkkynen, V.-P. (2019). The energy of Russia. Hydrocarbon culture and climate change. Edward Elgar Publishing, 2019.

Volchkova, N.A. and Turdyeva, N.A. (2016). Microeconomics of Russian import substitution. Journal of the New Economic Association, 4(32), 140-146.

Worldbank (2019). Weaker global outlook sharpens focus on domestic reforms. Russia Economic Report 42, December 2019.

BOFIT Policy Brief

https://www.bofit.fi/fi/julkaisut/policy-brief/

http://www.bofit.fi • email: bofit@bof.fi

ISSN 2342-205X