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CARBON EMISSIONS EMBODIED IN RUSSIA'S TRADE: IMPLICATIONS FOR CLIMATE POLICY[1]

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Abstract

According to the current international climate change regime, countries are responsible for greenhouse gas (GHG) emissions that result from economic activities within their national borders, including emissions from producing goods for export. At the same time, imports of carbon-intensive goods are not addressed by international agreements, including the Paris Agreement that was adopted in 2015. This paper examines emissions embodied in Russia's exports and imports based on the results of an input-output analysis. Russia is the second largest exporter of emissions embodied in trade and the large portion of these emissions is directed to developed countries. Because of the large amount of net exports of carbon-intensive goods, the current approach to emissions accounting does not suit Russia's interests. On the one hand, Russia, as well as other large net emissions exporters, is interested in the revision of allocation of responsibility between exporters and importers of carbon-intensive products. On the other hand, both the commodity exports structure and relatively carbon inefficient technologies make Russia vulnerable to the policy of "carbon protectionism," which can be implemented by its trade partners.

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Introduction

Climate change is one of the acute global issues extensively damaging the world economy. According to Intergovernmental Panel on Climate Change (IPCC), anthropogenic GHG emissions, primarily CO_2, are the main cause of climate change (IPCC 2013).

International climate cooperation that started in the 1990s made it necessary to account for emissions associated with separate countries. The key issue is how to define which country is responsible for emissions. In order to fulfill obligations under international agreements (the Kyoto Protocol and Paris Agreement), countries prepare national inventories containing information about the emissions that take place "within national territory and offshore areas over which the country has jurisdiction" (IPCC 2006).

This approach is the most transparent and feasible but has some drawbacks because it does not address international trade flows. Meanwhile, around 30% of global CO_2 emissions are released during the production of internationally traded goods (Sato 2014). Therefore, an increase in the consumption of carbon-intensive goods in one country may not lead to an increase in its emissions, but will contribute to an increase in emissions in other countries who are suppliers of carbon-intensive products.

This situation is aggravated by the fact that most of the carbon-intensive trade flows are directed from developing to developed countries. Developing countries are not listed in Annex I of the United Nations Framework Convention on Climate Change (UNFCCC) and therefore have not taken quantitative commitments for emissions reduction under the Kyoto Protocol. This means that the growth in carbon intensive product consumption in developed countries, which is related to imports from developing countries, is not regulated within the international climate change regime. Moreover, it induces "emission (carbon) leakage," that is, the increase in emissions outside developed countries due to rising imports of carbon-intensive products from developing countries (as a result of the policy to cap emissions).

There is an alternative approach to emission accounting based on the consumption, not the production of a particular country. According to this approach, emissions that have occurred abroad due to production of imported goods are accounted along with emissions from domestic final consumption. In this case, preconditions for "emission leakage" disappear and additional incentives for reducing consumption (but not production and exports) of carbon-intensive products arise. According to Peters et al. (2011), net embodied emissions exports from developing to developed countries increased from 0.4 Gt CO_2 in 1990 to 1.6 Gt CO_2 in 2008, which exceeds the Kyoto Protocol emission reductions. Aichele and Felbermayr (2015) calculated that Kyoto commitments had led to growth in embodied carbon imports of committed countries from non-committed ones by around 8%.

Global production-based and consumption-based emissions are equal. However, they vary in different countries. According to Peters and Hertwich (2008), in 2001 total consumption-based emissions of Annex I countries were 5% higher than their production-based emissions. In particular, in 2001 the USA's consumption-based emissions exceeded its production-based emissions by 7.3%. Unlike the USA, the production-based emissions of China and Russia were 17.8% and 21.6% higher than consumption-based emissions.

The difference between production-based and consumption-based emissions is their net emissions exports[4]. The gaps between national production-based and consumption-based emissions are defined by international trade flows of intermediate and final goods. The generally used assessment method for carbon content of trade ("virtual carbon"[5]) is input-output analysis (IOA), which allows us to take the whole supply chain into account.

Emissions embodied in trade constitute a significant part of global emissions and estimating them is necessary to assess the actual carbon footprint of countries (consumption-based, not production-based). This paper discusses the results of analysis of inter-country input-output tables aimed at calculating emissions embodied in exports and imports of major countries and Russia in particular. In this paper, we estimate the volume of emissions embodied in Russia's exports and imports. The main hypothesis is that due to Russia's large 'virtual carbon' exports, the international climate change regime based on production-based emissions accounting doesn't suit Russia's interests.

This paper is organized as follows. The second section contains the description of main approaches to the estimation of emissions embodied in international trade along with the related literature review. The third section focuses on the estimates of volumes and the structure of emissions embodied in Russia's exports and imports, as well as a comparison of Russia's numbers with estimates for other countries. This section also explains reasons for the large carbon intensity of Russia's exports. The fourth section addresses a question about the implications of the study's results for Russia's position in international climate change negotiations. Specifically, it is argued that Russia has reasons to claim for sharing responsibility for emissions from the production of carbon-intensive goods between their exporters and importers. At the same time, taking virtual carbon into consideration can make Russia vulnerable to "carbon protectionism" measures, which can be taken by developed countries. The final section concludes the paper and summarizes its main results.

Methodology and literature review

Currently, there are two main approaches to embodied emissions assessment: environmentally extended bilateral trade (EEBT) and multi-regional input-output analysis *(MRIO*) (Peters 2007). These approaches not only differ in data source (national input-output (IO) tables for EEBT and MRIO tables for MRIO), but also in the manner they account for emissions embodied in trade during the different stages of final goods production.

The difference between the two approaches can be illustrated with the following example. Assume country A imports a car from country B. Using the EEBT approach, emissions embodied in imports include only emissions related to production of a car itself, whereas emissions from mining of iron ore in country C and smelting of the steel in country D would be imports of country B from countries C and D (The Carbon Trust 2011).

Using the MRIO approach, CO_2 emissions associated with the production of the car – mining of iron ore for the steel, smelting of the steel, and the assembly of the car – would be considered

[4] $E_{prod} = E_{cons} + E_{exp} - E_{imp}$, where E_prod – production-based emissions, E_cons – consumption-based emissions, E_exp – emissions embodied in exports, E_imp – emissions embodied in imports.

[5] The term originated from "virtual water" (Atkinson et al., 2011), the amount of water used for production of a particular good.

imports of country A from countries B, C, and D. The MRIO approach therefore allows for analyzing the whole life cycle of a good and most completely assesses “virtual carbon” volumes.

There are more and more studies using IO analysis for accounting emissions embodied in exports of a particular country (primarily for China – the largest emitter and exporter of CO_2 emissions (Peters et al. 2007; Xu, Allenby, and Chen 2009; Liu et al. 2010; Lin and Sun 2010; Dietzenbacher, Pei, and Oosterhaven 2012; Su, Ang, and Low 2013; Winchester, Karplus, and Zhang 2014; Liu, Peng, and Xianqiang 2016) and emissions embodied in global exports[6].

Ahmad and Wyckoff (2003) found that total CO_2 emissions embodied in exports were comparable with (and in many cases exceed) total emissions of particular countries. Most developed countries are net importers of emissions, whereas developing countries are primarily net exporters of emissions. In 1995, the net exports of China and Russia were almost equal to the net imports of the OECD region (Ahmad and Wyckoff 2003). Nevertheless, some studies reveal some developed countries with energy-intensive exports to be net exporters of emissions: Australia (Lenzen 1998), Norway (Peters and Hertwich 2006), Sweden (Kander and Lindmark 2006) and Canada (The Government of Canada 2002).

Peters and Hertwich (2008) estimated the trade-related CO_2 emissions of 87 countries in 2001. Global emissions embodied in exports accounted for 5.3 $GtCO_2$. The authors point out that the current international climate change regime is inefficient because it is mainly net importers of emissions who have taken quantitative commitments under the Kyoto protocol. They suggest including trade effects in national emission inventories and allocating responsibility in accordance with regional groups, not countries, which could lessen the influence of trade on CO_2 increases (Peters and Hertwich 2008).

Davis and Caldeira (2010) calculated CO_2 emissions embodied in exports for 113 countries and 57 industries. In 2004 they were around 6.2 $GtCO_2$ (later the result was corrected to 6.4 $GtCO_2$ (Davis, Caldeira and Peters 2011)), and most of the emissions embodied in trade occurred as exports from China and other developing countries to OECD countries. In Switzerland, Sweden, Austria, the United Kingdom, and France more than 30% of consumption-based emissions were embodied in imports, and in China 22.5% production-based emissions were embodied in exports. The authors conclude that the allocation of responsibility between producers and consumers of emissions is important for developing an effective climate agreement (Davis and Caldeira 2010).

Boitier (2012) used the MRIO method in order to calculate emissions embodied in trade for 40 countries and 35 industries based on World Input-Output Database (WIOD) data from 1995 to 2009. The author distinguished “CO_2-consumers” (OECD countries, especially EU-15, where consumption-based emissions exceed production-based emissions) and “CO_2-producers” (developing countries – BRIC and “Rest of the World”). The author suggests implementing not only production-based but also consumption-based CO_2 accounting, which would allow for the elaboration of more objective targets for climate change mitigation policy. Moreover, it is assumed that for most countries that didn’t sign Annex I of UNFCCC, using consumption-based CO_2 accounting for determining national reduction targets would be preferable and probably stimulated taking quantitative commitments for emission reductions (Boitier 2012).

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[6] For an overview see: Wiedmann (2009), Sato (2014), Lininger (2015).

Most studies devoted to calculation of emissions embodied in trade include assessment of emissions embedded in exports and imports of Russia (Boitier 2012; Peters and Hertwich 2008; Davis, Caldeira, and Peters 2011). However, there are few studies discussing the carbon content of Russia's trade in depth (i.e. apart from indicating total values).

Emissions embodied in Russia's exports and imports were estimated in 2011 by a Russian-Indian research group that used the *EEBT* method and the IO tables of Rosstat (2002), trade statistics, and carbon intensities of industries. Emissions embodied in exports in 2002 accounted for 373 Mt; emissions embodied in imports were about 203 Mt. The authors concluded that the largest importers of emissions from Russia are European countries and China, which is related to the high value of exports of mineral resources (Mehra et al. 2011). It was assumed that the technology (and hence carbon intensity) of Russian exports is equal to the imports technology, which leads to some bias.

Piskulova, Kostyunina and Abramova (2013) analyzed exports of Russian regions concerning possible changes in Russian trade partners' climate policies. The authors showed that carbon intensity of a large number of Russian regions is quite high and the implementation of border carbon adjustment (BCA) by Russian trade partners could be damaging. This study did not include quantitative assessment of emissions embodied in Russian exports.

To estimate emissions embodied in exports, we use the World Input-Output Database (WIOD, 2015), which contains national and world IO tables. World IO tables are constructed using national IO tables and/or supply-and-use tables, UN COMTRADE trade statistics, OECD, Eurostat, IMF and WTO for services trade data, and others (Timmer 2012). The methodology is explained in detail in Makarov and Sokolova (2014). The analysis conducted in this paper is based on emissions data from 2000-2011 due to the availability of extended input-output data in the WIOD database. We may expect that beginning in 2014 the volume of emissions embodied both in exports and imports decreased due to the drop in Russia's foreign trade. However, exact estimates may only be done when all the necessary data for 2014 is published.

Main findings

Emissions embodied in Russia's exports and imports

Currently, Russia ranks fourth in the world (after China, the United States and India[7]) in the production of carbon emissions, and if taking into account land use, land-use change, and forestry (LULUCF), it is probably behind Brazil and Indonesia. The Soviet industrialization of the 1930s-1980s was accompanied by rapid growth in GHG emissions. For 70 years, the Soviet Union has increased annual CO_2 emissions more than 100-fold (from 11.2 Mt in 1922 to 1.1 Gt in 1988), and before its collapse, the volume of its emissions was very close to that in the United States (Marland et al. 2011). After the collapse of the USSR, Russia experienced a painful transitional crisis that resulted in a sharp, 42.5%, GDP fall[8], and many enterprises were dissolved. One of the external effects of the crisis was the reduction of CO_2 emissions (see Figure 1). By 1998, CO_2 emissions (not including LULUCF) decreased by 42.5% in comparison to 1990. Economic recovery since 1999 has not returned Russia to its previous level of emissions, as it has been accompanied by

[7] According to UNFCCC.
[8] According to World Development Indicators.

industry restructuring; the carbon-intensive industries that dominated in the Soviet era have been replaced by the service sector (Grigoryev, Makarov, and Salmina 2013). During the first decade of 21st century, carbon emissions slightly increased, and in 2014 they were 33.3% lower than in 1990[9].

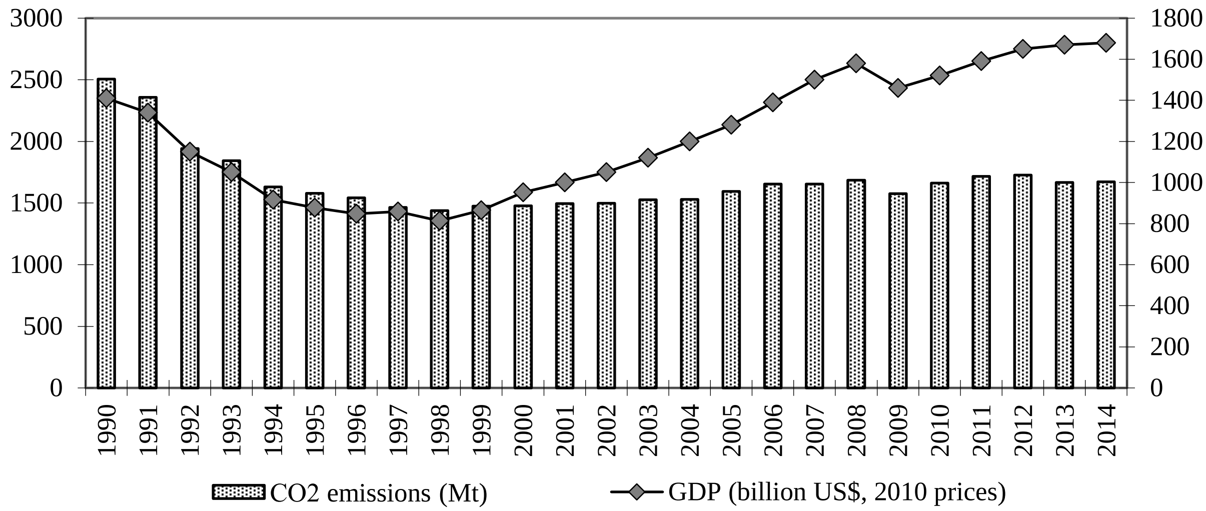

Figure 1 CO_2 emissions (left axis) and GDP (right axis) in Russia in 1990-2014
Source: Based on data obtained from UNFCCC (2016) and World Bank (2016).

It could be expected that dynamics of emissions embodied in Russia's exports coincide with dynamics of total emissions. However, it has been revealed that this is not true. In 2011, Russia exported 541 Mt of CO_2 (Figure 2). This is the highest value since 2007, but it is still 18% lower than in 2000. In 2000, Russia exported 45% of total emissions, in 2011 – only 32%. This tendency might seem odd because the export value (US dollar, current prices) rose 5-fold from 2000 to 2011 and production-based emissions (according to UNFCCC national inventories) increased by 11%[10]. However, the export volume index[11], reflecting real export volumes, reached only 140% by 2011 (base year 2000)[12]. A 40% increase of commodity exports was compensated, on the one hand, by technological improvement, and on the other hand by simplification of export structure (production of final goods, which requires burning large volumes of domestic fossil fuel, is associated with higher emissions volumes than selling raw mineral fuels).

Emissions embodied in Russia's imports increased 4.4-fold from 2000 to 2011 (see Figure 2). The reasons were rising commodity import volume and substitution of imports of European goods by more carbon-intensive Chinese goods. However, emissions embodied in imports in 2011 accounted for only 161 $MtCO_2$ – 3.4 times less than emissions embodied in exports.

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[9] According to UNFCCC.
[10] According to UNFCCC.
[11] The ratio of export value index and national currency value index.
[12] According to World Development Indicators.

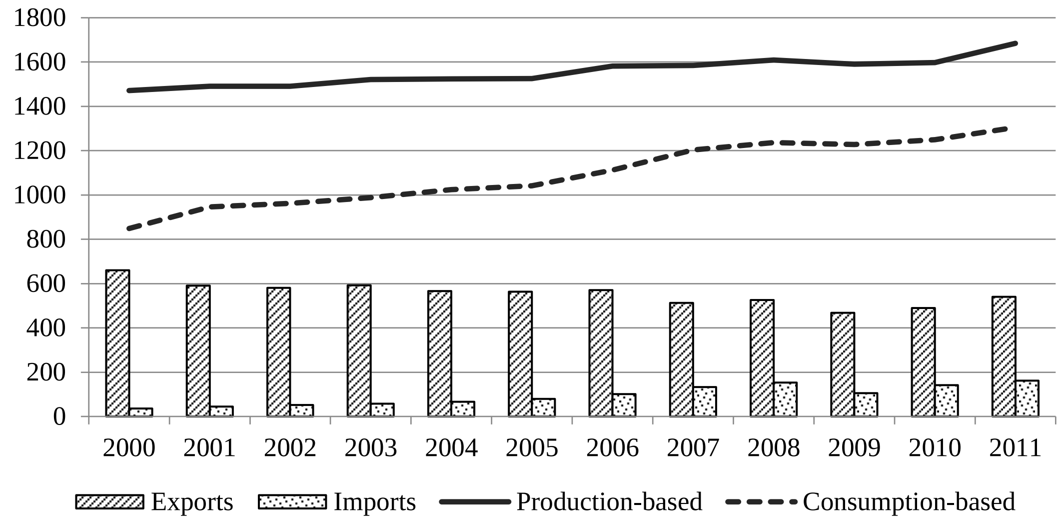
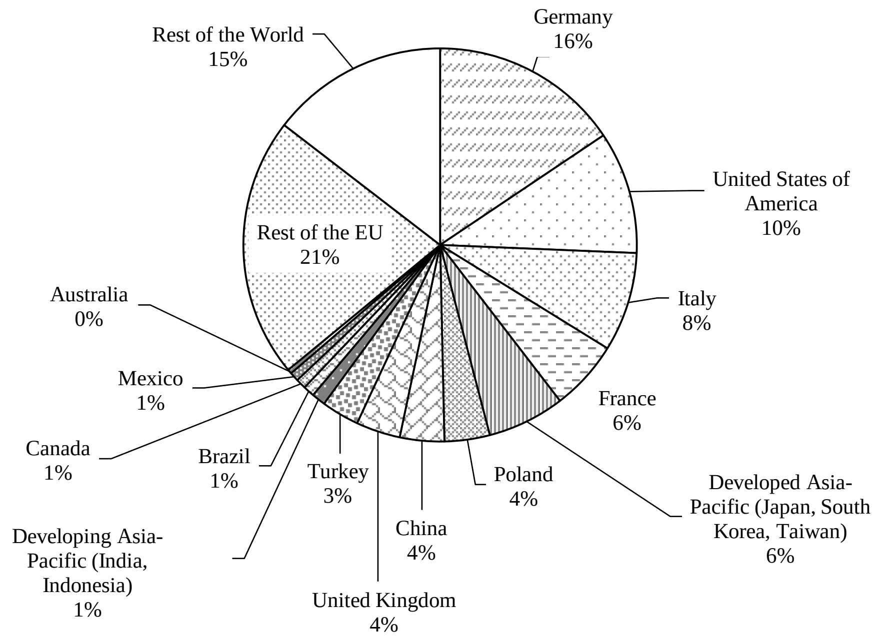


Figure 2 Production and consumption-based emissions, CO_2 exports and imports, Mt, 2000-2011
Source: Authors' calculations, based on UNFCCC (2015) and WIOD (2015).

Emissions embodied in exports are represented primarily by the category "Electricity, Gas and Water Supply" (42% of emissions embodied in exports). This category includes emissions for generating electricity that is further used for either producing exported manufacturing goods, or for direct exports. Emissions from burning exported fuels are not included in emissions embodied in exports, but emissions from their extraction do fall into the category "Mining and Quarrying" (14% of emissions embodied in exports) that also includes emissions from associated gas flaring. Despite significant reductions in recent years, Russia is still the world's leader in gas flaring – the amount of gas flared in Russia was 35 bcm in 2012 (World Bank 2014). The industrial structure of emissions embodied in imports is more differentiated than that of emissions embodied in exports, which is determined by the more complicated structure of Russian imports in comparison to exports.

Analysis of the geographical structure of emissions embodied in Russian exports and imports reveals interesting patterns. A large part of emissions embodied in Russia's exports in 2011 was directed to the USA (see Figure 3). This might seem odd because of the low volume of exports from Russia to the United States, but the reason lies in methodological features. The MRIO method considers emissions embodied in exports from Russia to the USA as not only emissions associated with the manufacturing of exported final products, but also emissions associated with mining of resources exported to China, the EU and other countries and then used there for the production of goods exported to the USA. Therefore, directions of Russian emission exports using the MRIO method are defined not by directions of Russian commodity exports, but by global trade flows. Comparing emissions export data in 2000 and 2011, China's share significantly increased (from 4% to 10%) and Germany's share declined (from 16% to 6%). The share of the EU countries decreased from 59% to 40%. As for the geographical structure of imports, it changed drastically over 10 years. In 2000, China represented only 10% of emissions embodied in Russian imports; in 2011, its share had reached 39%.



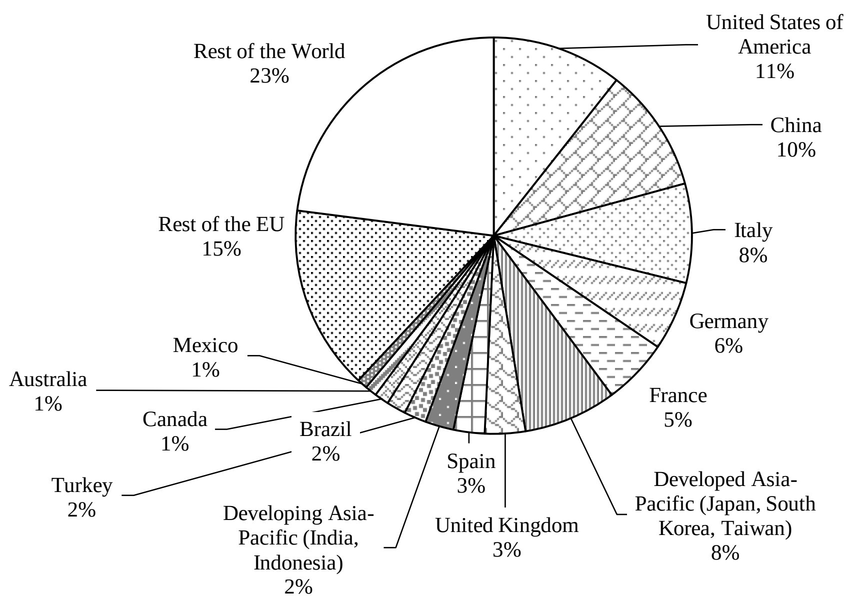


Figure 3 Structure of emissions embodied in Russia's exports in 2000 (top) and 2011 (bottom), by partner[13]
Source: Authors' calculations based on data from UNFCCC (2015) and WIOD (2015).

[13] Due to lack of data we had to include a range of Russia's large trade partners in the category "Rest of the world" (Ukraine, Belarus, Kazakhstan).

Comparison of emissions embodied in trade in Russia and other countries

The accounting of production-based and consumption-based CO_2 emissions reveals different results. For example, China's share of global production-based CO_2 emissions in 2011 was 30%, whereas its share of global consumption-based CO_2 emissions was only 25%. The USA demonstrates the opposite tendency: its share of global production-based CO_2 emissions was 19%, while its share of consumption-based CO_2 emissions accounted for 21% (see Table 1).

Table 1 Emissions embodied in exports and imports of the main CO_2 emitters in 2000 and 2011

№	Country	Production-based emissions, Mt	Consumption-based emissions, Mt	Emissions embodied in exports, Mt	Emissions embodied in imports, Mt	Net emission exports, Mt	Share in production-based emissions, %	Share in consumption-based emissions, %
2000								
1	USA	5962.7	6643.2	486.6	1167.1	-680.5	24%	27%
2	China	3607.5	3093.2	696.7	182.3	514.3	15%	13%
3	Russia	1471.3	848.6	659.4	36.7	622.8	6%	3%
4	Japan	1251.5	1496.1	190.5	435.1	-244.6	5%	6%
5	India	1023.8	922.3	174.9	73.4	101.6	4%	4%
6	Germany	891.4	1101.5	212.4	422.5	-210.1	4%	4%
7	Canada	564.6	503.5	208.6	147.5	61.1	2%	2%
8	UK	555.2	685.6	126.8	257.2	-130.4	2%	3%
9	South Korea	463.3	434.3	147.5	118.6	29	2%	2%
10	Italy	462.3	577.5	103.9	219.1	-115.2	2%	2%
2011								
1	China	9034.7	7503.4	2116.4	585	1531.4	27%	23%
2	USA	5603.8	6303.6	522.5	1222.3	-699.8	17%	19%
3	India	1860.9	1782.2	319	240.3	78.7	6%	5%
4	Russia	1684.4	1304.9	540.7	161.2	379.6	5%	4%
5	Japan	1240.7	1475.1	249.9	484.3	-234.4	4%	4%
6	Germany	798.1	981.3	243.4	426.7	-183.3	2%	3%
7	South Korea	611.7	555.8	236.8	181	55.9	2%	2%
8	Canada	555.6	593.2	180.3	217.8	-37.6	2%	2%
9	UK	464.6	604.4	118.5	258.3	-139.8	1%	2%
10	Mexico	458.1	505	87.5	134.4	-46.9	1%	2%

Source: Authors' calculations, based on data from UNFCCC (2015) and WIOD (2015).

In Russia, production-based and consumption-based CO_2 emissions also differ significantly. Russia is the fourth largest CO_2 emitter and its share of global production-based emissions is 6%.

Under the consumption-based approach, Russia is responsible for only 4% of global emissions and cedes the fourth place to Japan.

The gap between production-based and consumption-based CO_2 emissions is determined by large Russian emission exports (even larger than US exports, despite the huge difference in commodity export volumes) and by extremely low emission imports (Russia isn't even listed among top 10 countries).

Russia was the global leader in net emissions exports as far back as in 2000. However, its net emissions exports have declined by 40%, whereas the numbers for China have increased almost threefold. As a result, currently, Russia is the second largest exporter of CO_2 emissions after China. The gap between Russia and China is fourfold. However, Russia's net emissions exports are 4.8 times higher than that of the third largest emitter – India.

Russia is one of the leaders in export share in production-based emissions. 32.3% of emissions within national borders are exported, which is much higher than in China (23.4%) and the USA (9.3%). On the contrary, Russia's imports share of consumption-based emissions (4.3%) is low in comparison to other large economies – China (7.8%), India (13.5%), and the USA (19.4%). For leading European countries – Germany, the United Kingdom and Italy – this figure exceeds 40% (see Table 1).

Reasons for large volumes of emissions embodied in Russia's exports

On the one hand, the large volumes of emissions embodied in Russia's exports are explained by the commodity structure of its exports, which is primarily represented by fuels and energy-intensive industries. Countries with a high export share in production-based emissions are South Korea, Canada, Russia, and Germany. In the case of South Korea and Germany, this is explained by a high export quota, and in the case of Russia and Canada, the only explanation is a distortion of the structure of exports towards energy-intensive products.

On the other hand, net exporters of emissions are mainly Asian and Eastern European countries. These countries have a high carbon intensity of exports (and Russia is the leader), which is defined as the ratio of emissions embodied in exports to the value of commodity exports (see Figure 4). This allows us to presume that large volumes of emissions embodied in exports are determined by relatively low carbon efficiency associated with general technological "backwardness" that is typical for developing countries and economies undergoing a transition from a command-and-control to a market economy.

In order to assess the influence of technological factors on Russia's emission exports, it is possible to calculate CO_2 emissions embodied in Russia's exports with the use of input-output tables, making the assumption that for the given volumes and structure of exports it uses "world average" technologies[14]. Calculation results are shown in Figure 5. Under the assumption that Russia uses "world average" technologies, Russia's emissions exports in 2011 would decline 1.65-fold (from 541 to 327 $MtCO_2$) (Figure 5). Therefore, approximately 60% of emissions embodied in Russia's

[14] For this purpose, we substitute technological coefficients in input-output tables by GDP-weighted average volume of resources pet unit of output. The data on national output and final consumption of goods and services remains unchanged. We also assume that carbon intensity coefficient of an industry is equal to a corresponding world average coefficient weighted by the countries' shares in global output of that industry.

exports are determined by the volume and the trade structure of its exports, and 40% is determined by its lagging behind global average technology.

Using the assumption that global weighted average technology is used in all Russia's trade partners, Russia's emission imports would increase 1.09-fold (from 161 to 176 MtCO_2 in 2011). This means that Russia imports production mainly from countries with more carbon efficient technologies in comparison to the world average.

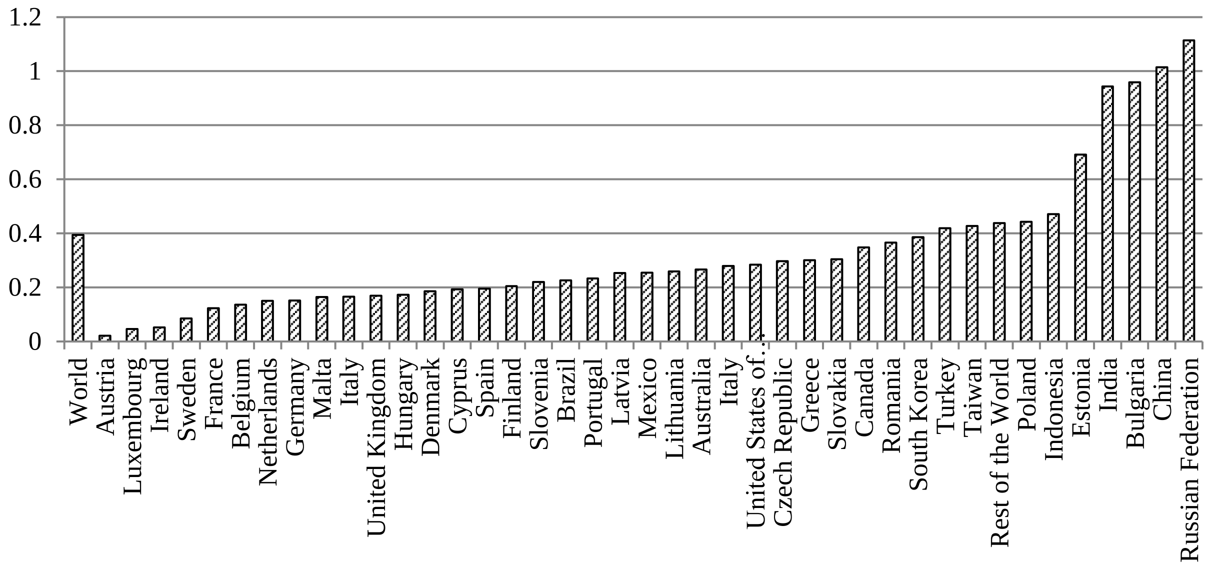


Figure 4 Carbon intensity of exports in 2011, tCO_2/thousand US$

Source: Authors' calculations, based on data from UNFCCC (2015) and WIOD (2015).

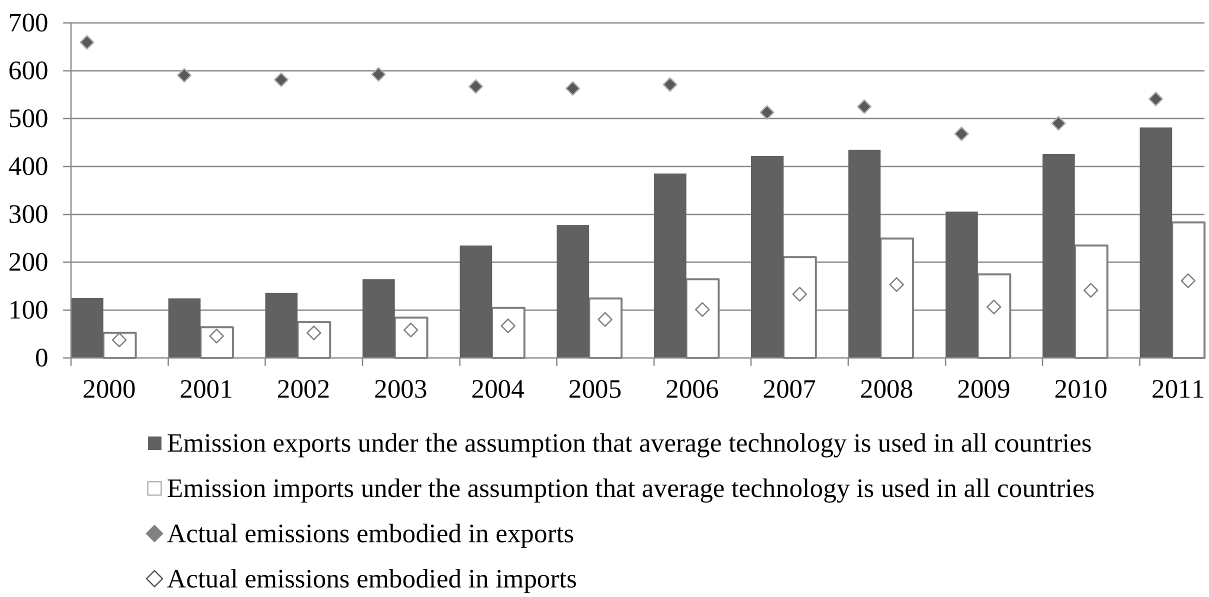


Figure 5 CO_2 emissions embodied in Russia's exports and imports in 2011: Actual values and those under the assumption that weighted average technologies are used all over the world

Source: Authors' calculations, based on data from UNFCCC (2015) and WIOD (2015).

Illustrative here is the comparison of the countries' net exports under the assumption of weighted world average technology in all countries. This allows us to exclude the effect of technologies and determine how countries vary in exports of emissions due to the volume of their commodity exports and foreign trade specialization. If the whole world switches to weighted world average technology, Russia would still take the second place in net emissions exports, following China (Figure 6). This is evidenced by the fact that the dominating factor of large net emission exports in Russia is not carbon inefficient technologies, but trade surplus and the existing foreign trade structure.

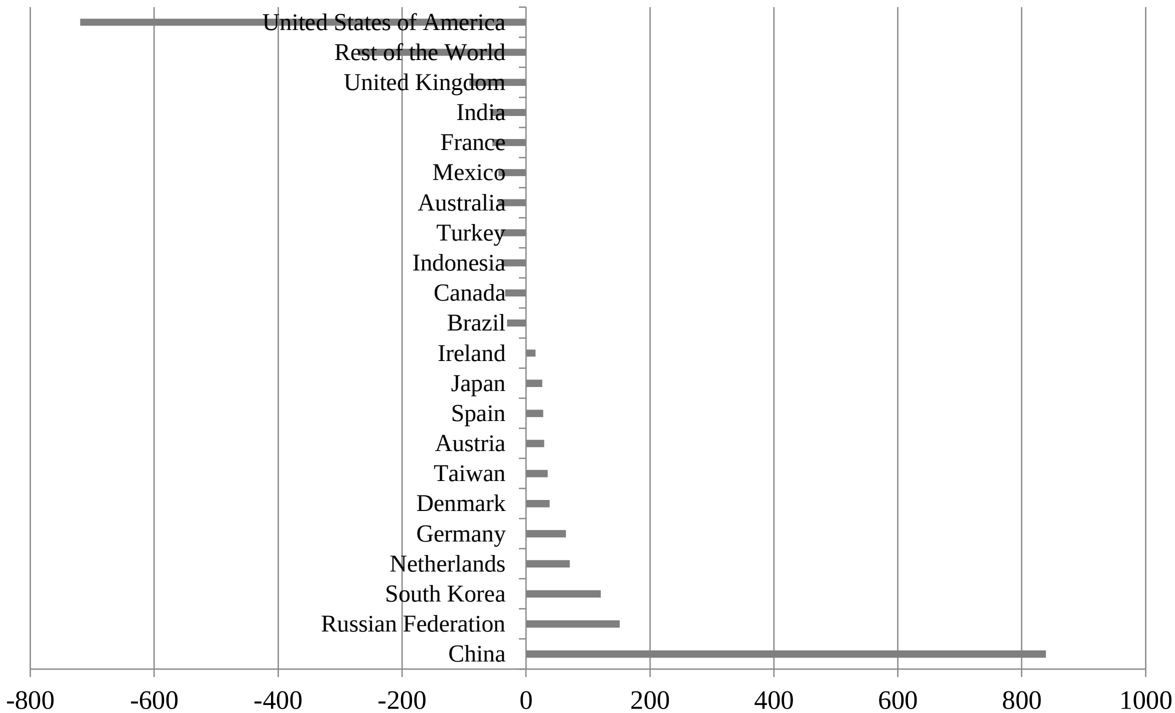


Figure 6 Net CO_2 emissions exports in 2011 under the assumption that all countries use weighted world average technology
Source: Authors' calculations, based on data from UNFCCC (2015) and WIOD (2015).

Discussion

The features of methodology and the structure of the data used in this study impose some constraints on the accuracy of the estimates. However, the main point is that analysis conducted in this paper, as well as preceding research (Peters and Hertwich 2008; Peters 2011; Davis, Caldeira and Peters 2011; Boitier 2012; Aichele and Felbermayr 2015) show that flows of emissions embodied in trade are too large to ignore them within the international climate change regime. Most of the emissions embodied in trade are directed from emerging economies (including Russia) to developed countries.

Emissions embodied in trade and the new climate agreement

The Kyoto Protocol put on countries the responsibility to reduce production-based, not consumption-based carbon emissions. At the same time, according to the principle of common but differentiated responsibilities, this responsibility was imposed only on developed countries and those with economies in transition (in other words, UNFCCC Annex I countries). As a result, taking into account that most emissions were exported from developing to developed countries, neither exporters (leading developing countries, non-Annex I) nor importers (developed countries, obliged to reduce domestic emissions only within national borders) undertook obligations to reduce these emissions.

Nowadays, the described regulation failure does not have much importance simply because the Kyoto Protocol is not the central element of the international climate regime anymore. Though it is still in effect (the second commitment period will finish in 2020), the Paris Agreement that was adopted in 2015 and came into force on November 2016 is much more important for the future of international cooperation for coping with climate change.

Unlike the Kyoto Protocol, the Paris Agreement transforms the principle of common but differentiated responsibility: developing and developed countries participate on equal terms. In order to guarantee compromise between actors who often have opposite interests, the agreement provides a framework for further actions rather than defining them. The word "commitments" in the text of the agreement is replaced by "contributions" (intended nationally determined contributions, INDC). These contributions are defined by nations themselves, and contain emission reduction targets that are non-binding.

Although the Paris Agreement sets an ambitious goal of "holding the increase in the global average temperature to well below 2°C above pre-industrial levels" (and even pursuing efforts to limit it to 1.5°C) (United Nations 2015), the implementation of INDCs provided by December 2015 will not be sufficient to limit the temperature increase to less than 3°C by 2100 (UNEP 2016). The form of INDCs is not strictly standardized, and in theory, parties could include into submitted contribution the intended reduction of either production-based or consumption-based emissions. However, the intended national contributions submitted so far refer to the reduction of production-based emissions only, either in absolute terms or as a ratio to GDP. This means that the new agreement does not change the situation when the national reduction targets (binding or non-binding) can be completed due to the substitution of domestic production of carbon-intensive products by imports.

The allocation of responsibility between exporters and importers

Under the Kyoto Protocol, developing countries, concentrating an increasing share of carbon-intensive production, did not have any quantitative commitments to reduce emissions, thus no one took responsibility for the emissions embodied in developed countries' imports. Since production in developing countries is on average more carbon intensive than in developed countries, this failure of climate regulation contributed to the increase of global emissions.

Under the Paris Agreement, all the major emitters are pledged to reduce or limit their emissions in accordance with their INDCs that would mitigate the situation. Now the key issue is not the lack of responsibility for emissions embodied in trade, but the fairness of allocation of this responsibility between exporters and importers. Placing all the responsibility for emissions embodied in trade on the exporter is not fair: an importer should be responsible because its demand predetermines emissions. At the same time, shifting all the responsibility to the importer is not correct, because an exporter, releasing emissions by producing an exported good, receives a payment from an importer (Sato 2014). There can be different forms of joint responsibility. For example, contributions under the new agreement could be recalculated considering emissions embodiment in trade (net exporters could submit smaller contributions and net importers larger contributions compared to those based on production-based emissions only). The main issue is how to allocate the responsibility for emissions reduction between an importer and an exporter of carbon-intensive products. The simplest approach is to divide responsibility proportionally – for instance, to calculate arithmetic mean between reductions under production-based and consumption-based accounting. Shared responsibility can also be defined on the basis of the best available technologies. Such an approach "allocates the responsibility between the producers and the final consumers based on the real capacity of each agent to reduce emissions" (Berzosa et al. 2014). More complex approaches rely on game theory (Granot et al. 2014).

The Paris Agreement introduces a new mechanism applied at international level – the Sustainable Development Mechanism (SDM) (United Nations 2015). To some extent, it is a re-launch of the Kyoto Protocol's clean development mechanism (CDM), which assumed that Annex I countries could implement clean projects in developing countries on account of their commitments. However, CDM was not effective enough, primarily because of difficulties in assessing the environmental effects of investment projects under a business-as-usual scenario. It was revealed that many of CDM projects would be accomplished without any climate finance, just in the process of equipment modernization. In these cases, CDM was only a transfer of financial resources from developed to developing countries and did not result in climate change mitigation (Wara 2007).

Under the new circumstances, SDM could be implemented as a mechanism of financing (on account of the net importers' contributions) of projects aimed at reducing emissions embodied in exports. In order to avoid imperfections of the initial implementation, SDM could be limited by the framework of a value chain. For example, it could be applied only to enterprises oriented to exports to the country that provides SDM investment.

One more instrument that can allocate responsibility between an exporter and an importer is border carbon adjustment, which assumes imposing an additional tax on imported carbon intensive products (Ismer and Neuhoff 2007). In theory, the volume of this tax should be calculated as a difference in volumes of emissions released during the production of one unit of imported product and its domestic analog, multiplied by the carbon price (for example, defined by national emissions trading scheme). In fact, it is often suggested that carbon taxes should be imposed on products imported from countries without an emissions regulation system.

A result of imposing border carbon adjustment is that part of the costs associated with its implementation falls on consumers of the importing country, who have to pay higher prices for imported goods, on which a carbon tax is imposed. Another part of the costs falls on exporters because of declining competitiveness of their products in importing country.

Border carbon adjustment is a powerful tool to prevent "carbon leakage" and to stimulate emission reduction in developing countries (Branger and Quirion 2014), which also can fix distortion in responsibility allocation between importers and exporters of carbon-intensive products. At the same time, border carbon adjustment has obvious drawbacks, including welfare losses in both exporting and importing countries and possible initial conflict of such measures (they are often called "carbon protectionism"). Finding a compromise while allocating responsibility for emissions reductions, which implies mutual consideration of interests by net exporters and net importers, and elaboration of cooperative mechanisms to reduce emissions embodied in exports (as technology transfer or as economic flexibility mechanisms) are more appropriate measures for enhancement of the international climate change regime in the future.

Consumption-based emissions and Russia's interests

The current approach to emissions accounting based on calculating emissions from production corresponds to Russia's interests to a lesser extent than to the interests of other countries. A substantial part of Russia's emissions is associated with consumption by developed countries, but according to the climate agreements, Russia is solely responsible for these emissions.

Hence, Russia is interested in the re-allocation of responsibility for CO_2 emissions between exporters and importers of carbon-intensive products. Other major net exporters of emissions – China and India – could also support this idea. None of the three countries is interested in the complete substitution of production-based emission accounting by a consumption-based one. The shift to 100% consumption-based accounting would assume regulation of individual consumer behavior instead of industrial emissions. This would only be possible through imposing consumption taxes or implementing border carbon adjustment, which would have a negative impact on imports and therefore national welfare. At present, the key issue is not to substitute but to supplement production-based emissions accounting with accounting that is consumption-based during the UN negotiations, with the possible implementation of responsibility allocation schemes.

The expert community has long been aware of the importance of accounting for emissions embodied in trade. However, the rules of emissions accounting have been based entirely on production-based emissions for too long and are resistant to such fundamental changes. Though in Canada and in the EU some elements of consumption-based emissions accounting are used on the national and local levels[15], in general, developed countries have little incentive to promote this idea globally as it would undermine their last decade of success in reducing emissions. Developing countries, most importantly China and India, hadn't previously considered the implementation of consumption-based accounting because before Paris they didn't have any commitments under international agreements. But since these two countries are now being involved actively in international climate cooperation, one can expect that the issue will be addressed more carefully.

For Russia, a change of accounting approach from production-based to consumption-based would lead to the following re-allocations: first, emissions from fossil fuels burned in order to produce non-energy exports would be attributed to their importers; secondly, the same would be true for emissions from the extraction of exported fossil fuels; thirdly, emissions from Russian electricity production directed to exports would be also attributed to importing countries.

At the same time, some emissions originating from Russian imports would be attributed to Russia. However, as the volume of emissions imports to Russia is much smaller than that of emissions exports, the ideas of consumption-based emissions accounting and sharing responsibility for emissions embodied in trade between exporters and importers of carbon-intensive goods could bring substantial benefits to the country. First, these ideas may represent an important argument in climate negotiations, the argument being that Russia releases emissions not only for itself but also for developed countries, providing opportunities to reduce their emissions. At present, Russia does

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[15] For Canada see McKewn, Bristow and Caouette (2016) and for the EU see Barrett et al. (2013) and Carbon-CAP Project publications, http://www.carboncap.eu/index.php.

not use this argument at all. Instead, it prefers to rely on another argument concerning the record-high emissions reductions achieved by Russia since 1990 (Kokorin and Korppoo 2013). However, this argument can hardly strengthen Russia's negotiating position as these reductions resulted mainly from the economic slowdown and natural restructuring of the Russian economy rather than from climate policy. Second, consumption-based emissions accounting may generate some green investment to Russia from importers of Russian products that would be interested in reducing emissions along the whole value chain.

Consumption-based emissions accounting would also bring Russia some risks. It is important to remember that allocation of responsibility for exported emissions between exporters and importers is justified only in relation to the part of emissions that is determined by large volumes and/or peculiarities of commodity structure of exports, and not by application of carbon inefficient technologies. The conducted analysis shows that this share of Russian emissions exports accounts for about 60% if global average technologies ae taken as a benchmark. The other 40% of emissions embodied in Russian exports results from technological lagging, and the responsibility for these emissions lies with Russia. This part of the emissions makes Russia especially vulnerable to border carbon adjustments, which can be introduced by its counterparts. This risk should be interpreted as an incentive to implement green technologies (including renewables), to reduce the carbon intensity of production and to activate a national climate policy in Russia. In this realm, Russia has not achieved any significant success as of yet (Makarov 2016; Kokorin and Korppoo 2013; Boute 2013).

Conclusion

Results of the study confirm the main hypotheses of the research:

1) Russia is the second largest exporter of emissions embodied in trade, following China. On the other hand, emissions imports by Russia are relatively low. Therefore, the production-based approach to emissions accounting used within international climate agreements does not suit the interests of Russia.

2) The high level of emissions embodied in Russia's exports is partly determined by the large volumes and commodity structure of its exports. Russia may claim for partial re-allocation of responsibility for these emissions to the importers of the corresponding production. However, a significant part of the emissions embodied in exports is explained by relatively carbon-inefficient technologies, and this fraction of emissions would remain the responsibility of Russia alone.

3) Consumption-based accounting and partial sharing responsibility for emissions embodied in trade can provide some benefits to Russia. First, large volumes of emissions embodied in exports represent an important argument in climate negotiations, because currently, consuming Russian exports allows its trade partners to reduce their production-based emissions. Secondly, consumption-based emissions accounting may create some incentives for importers of Russian products to make green investments into Russia in order to reduce emissions within a value chain. On the other hand, it may also become a strong argument for "carbon protectionism" measures. Given the large carbon footprint of Russian exports and the country's carbon-inefficient technologies, Russia would be very vulnerable to this policy.

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