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Comparing scenarios of the carbon regulation for the BRICS and EAEU economies using the GTAP-E model

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Abstract

The paper compares the economic effects of the introduction of a national carbon taxation and the emission trading system (ETS) between the EAEU and BRICS countries in the medium-term. We also add to this group of countries Uzbekistan, which has an observer status in the EAEU, and Turkmenistan, trade and economic partner of the EAEU. The static computable general equilibrium model GTAP-E is

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used. Targets for reducing emissions are formulated on the basis countries' intermediate goals, according to the national documents under the Paris Agreement. The results of simulations show that in terms of real GDP, countries such as Belarus, Russia, Kyrgyzstan, Kazakhstan, Armenia, Brazil, and India prefer an emission trading scheme to national taxation. While for China, South Africa, Uzbekistan and Turkmenistan, participation in the ETS leads to a greater reduction in GDP. Since the second group of countries has lower abatement costs than the equilibrium carbon price under the ETS, in the ETS scenario they reduce emissions by a greater amount and sell emission permits. The analysis also shows which sectors increase production after the carbon regulation. A considerable increase in production and exports is observed in chemicals, nonferrous, ferrous metals in several BRICS and EAEU countries. Despite that these industries are energy-intensive, countries decrease emissions by reducing production in the energy sectors. These industries can be potential joint comparative advantages in the context of declining demand for traditional energy sources. The findings can be useful for the integration policy.

Keywords: Computable general equilibrium model, Carbon regulation, CO_2 emissions, BRICS, EAEU, integrational policy

JEL: D58, F11, Q43, Q48, Q56

Introduction

Countries develop national climate policies and cooperate with other countries to meet the goals of the Paris Agreement. According to the IMF [Parry, et al., 2022], carbon pricing is an effective tool for reducing emissions. There are two main types of carbon pricing: a domestic carbon tax or an emissions trading system (ETS). According to World Bank data for 2023, 39 national jurisdictions have a carbon tax or emissions trading system[2]. Collaboration between countries is important for two reasons. First, countries trade with each other in energy products and energy-intensive goods. To avoid import tariffs that consider the carbon intensity of products, it is necessary to develop mutually accepted carbon regulation between trading partners. Second, international ETS allows to achieve a common goal of reducing emissions with less economic losses, as a common market makes the mechanism more flexible.

The BRICS is a group of countries that is aimed at stimulating trade and investment, including in the energy sector[3]. The EAEU is a Customs Union between Kazakhstan, Russia, Belarus, Armenia, and Kyrgyzstan that was established in 2015. The EAEU countries closely trade with China, India, and other BRICS countries. Kazakhstan expressed willingness to join BRICS[4], Belarus officially announced about applying for the BRICS membership in 2023[5]. This study is aimed at analyzing potential joint efforts of the EAEU and BRICS countries in the carbon taxation policy.

The current paper compares the economic effects of implementing an emissions trading system between the EAEU and BRICS countries and a carbon tax independently in each country using the computable general equilibrium model GTAP-E. The percentage reductions in emissions in the scenarios represent two-thirds of the targets, formulated in the official documents of the countries (NDC) by 2030 of the Paris Agreement, and can be considered as an intermediate goal until

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[2] The World Bank. 2023. "Carbon Pricing Dashboard." https://carbonpricingdashboard.worldbank.org/map_data.

[3] International Network for Economic, Social and Cultural Rights. "What you need to know about The BRICS New Development Bank." https://www.escr-net.org/sites/default/files/brics-ndb-factsheet-final-1.pdf.

[4] The Astana Times (2023). Kazakhstan Seeks to Join BRICS and Enhance Trade and Economic Cooperation. https://astanatimes.com/2023/06/kazakhstan-seeks-to-join-brics-and-enhance-trade-and-economic-cooperation/#:~:text=Kazakhstan%20is%20seeking%20to%20join,demonstrating%20collaboration%20between%20emerging%20economies.

[5] Ministry of Foreign Affairs of the Republic of Belarus. 2023. Statement by the Minister of Foreign Affairs of Belarus Sergei Aleinik at the BRICS Outreach and BRICS Plus Dialogues. https://mfa.gov.by/en/press/statements/b81aa8d4a1b18810.html

2030. We study the impact on the real GDP, production, trade flows, factors of production, prices, terms of trade. Analysis helps to identify countries with relatively lower abatement costs. Also, we study changes in the sectoral production in the context of declining global demand for traditional energy resources.

1. Existing approaches for studying carbon regulation studies using computable general equilibrium models

Simulation models assess the impact of carbon taxation on the economy of countries. The IMF [Parry, et al., 2022] calculates the additional benefits of reducing emissions from reducing population mortality due to environmental pollution. The growth from the additional benefits for Russia are approximately 2% of real GDP, the benefits for China are ~1.4%, for India are ~0.3% etc. Though countries will experience decline in production after introducing carbon taxation, if they do not take any measures, they risk experiencing the economic losses from climate change. [Nordhaus, 2006] shows that if the average earth temperature rises by 3°C, the negative impact on economic activity will be from 0.9 to 3% of global output.

Uneven introduction of the carbon regulation across countries is partially explained by the free-rider problem. For this reason, [Nordhaus, 2015] offers to introduce climate clubs – introduction of carbon tax inside countries-participants of the club and import tariffs on all goods imported from non-participants. It provides incentives for countries to join common carbon regulation without concerns about carbon leakage. In our paper we assume that all countries set emission targets and introduce carbon regulation simultaneously, because we rather concentrate on further development of BRICS and EAEU economies in the context of decline in demand for traditional energy products.

There are several articles that explore carbon regulation for the EU [Montenegro, et al., 2019], [Fragkos, et al., 2017]. Also, there are examples of ETS modeling among countries that already have national carbon emission regulation [Nong, et al., 2017]: Kazakhstan, South Korea, the EU, Norway, Switzerland, and New Zealand. For Kazakhstan, the carbon price for domestic regulation is lower than the equilibrium price for international ETS. As a result, Kazakhstan becomes a seller, while the EU becomes a buyer of emission allowances.

There are several papers that model international ETS with participation of China: [Zhang, et.al. 2017], study the effect of an emissions trading system between China, the United States, Europe, Australia, and the South Korea, [Ma, et al., 2019] evaluate the effect of ETS between China, Japan, and South Korea, [Siriwardana, et al., 2018] consider cross-country regulation for Australia, the USA, the EU, India and China, and other countries. In most of the studies China have initially lower abatement costs that is why under emission trading system becomes a seller of carbon allowances.

Some papers investigate large emitters of emissions [Thierfelder, et al., 2021]. Based on Global Trade Analysis Project (GTAP) 10 data, the authors analyze emissions for groups of countries, including Russia, China, India, South Africa, and other regions. The authors compared the effects of the energy consumption tax and the carbon tax using model GLOBE-EN. The carbon tax has proven to be more effective because, all other things being equal, it leads to a smaller reduction in countries' GDP. With global emission target of 20%, the largest GDP declines are in China, South Africa, and Russia (approximately from -0.2% to -0.5%).

Several studies look at certain countries. [Nong, 2020] uses the GTAP-E-PowerS model to study the economy of South Africa. There are number of studies on Chinese economy [Xu, et al., 2023], [Mu, et al., 2018], Kazakhstan economy [Kapsalyamova, et al., 2019].

Several studies analyze the energy transition in Russia. In the paper [Makarov, et al., 2020] authors used the Emissions Prediction and Policy Analysis MIT model to estimate the effect on Russia's GDP from a decrease in external demand for Russian energy products. The results show that Russia's GDP growth rate will be 0.5 percentage points lower if countries reduce demand to meet the obligations of the Paris Agreement. As practical recommendations, the authors suggest redirect investments in manufacturing, services, agriculture, and processing sectors. Using the same model, [Paltsev, et al., 2014] calculated the effect on the Russian economy of introducing a carbon tax in all regions simultaneously (reaching $ 160 per tone CO_2 by 2050). The results show that GDP decline may reach 10-20% compared to the baseline scenario without measures, due to lower external demand for traditional energy sources and the high cost of implementing renewable energy sources. In [Böhringer, et al., 2015] examines the environmental impact of Russia's WTO accession using the CGE model, which considers imperfect competition. The authors compare three policies to reduce CO_2: emission trading, introduction of emission intensity standards, and energy efficiency standards. The results show that emission trading system is preferable to other measures in terms of welfare gains.

Overall, the literature contains studies:

(1) conducted for certain countries to study the impact on sectors of the economy [Böhringer, et al., 2015], [Xu, et al., 2023], [Nong, 2020];

(2) with highly aggregated regions or large carbon-emitters [Thierfelder, et al., 2021], [Zhang, et.al. 2017], [Siriwardana, et al., 2018];

(3) that cover countries where some type of the carbon emission regulation already exists [Nong, et al., 2017], [Montenegro, et al., 2019].

However, estimates of the joint carbon regulation in the EAEU and BRICS, according to our knowledge, is not presented in the literature.

The paper also examines which industries can become new comparative advantages for these countries. According to [Volchkova, et al., 2016] based on the Hausmann-Klinger method, it was revealed that the chemical industry, machinery and equipment, and the textile industry can become joint potential comparative advantages for EAEU countries. The results can contribute to the literature on the development of the integration processes.

2. Description of the model and GTAP 10 data

The model is calibrated on the 10th version GTAP data 2014 which is developed by the Global Trade Analysis Project. This version includes 141 regions and 65 products and services [Aguiar, et al., 2019]. Data for Russia was added to the database in the 7th version of the GTAP [Turdyeva, et al., 2008]. The database was calculated based on the input-output tables from The Russian Federal State Statistics Service (Rosstat) for 2003. The GTAP project also contains behavioral parameters that include substitution elasticities for consumption and production, including for export and import solutions, and other parameters. The elasticities of substitution between different product origins are taken from [Hertel, et al., 2007]. Macroeconomic data on GDP, private and public consumption, and investment, trade flows, taxes are based on World Bank data, COMTRADE and IMF data. The GTAP database does not directly require the use of exchange rate data, as all values are expressed in thousands of US dollars. For a more detailed information, please, see [Aguiar, et al., 2019].

Data related to the energy sector includes data on CO_2 emissions and parameters, such as elasticity of substitution of capital, energy, and various types of fuel. There are also 5 energy products in the model and consumption of them leads to CO_2 emissions: coal, crude oil, natural gas, oil products, and gas. It is based on the data from the International Energy Agency. The initial quota amount for emissions is equal to actual emissions, and the tax is zero. In the current paper, the tax will be imposed on the intermediate usage of energy products by production sectors. Tax will be imposed on the intermediate usage of domestic as well as imported energy products.

As in the standard computable general equilibrium GTAP model, in this model perfect competition and constant returns to scale are assumed. The model is presented in the linearized form and solved using GEMPACK program. Detailed description of the model is presented in [McDougall, et al., 2007], that includes information how emission trading system is designed. In the scenarios carbon tax will be endogenously determined to achieve the required exogenous emission reduction.

For the current study, we assume that labor and capital are mobile between sectors, while land and natural resources are non-mobile, which means that they have a medium-term effect on the economy. Capital and labor are not mobile between regions.

The production function is modeled according to the “top-down” approach, when the overall structure of the economy is described, and energy consumption is based on the demand generated by the production sectors and households [Burniaux, et al., 2002]. This approach has an econometric justification. The production structure has the functional form of CES, which consists of several nested levels [Antimiani, et al., 2013]. Each level is a composite or sub-product containing factors of production or intermediate goods. For example, at the top level, the producer decides to allocate its costs between two sub-products: the sub-product of primary factors of production and energy, and the sub-product of intermediate goods. Due to the two-step budgeting theorem, the manufacturer can solve the problem in each node separately. Capital is contained in a single node with energy goods, this is explained by the fact that capital and energy goods can be replaced by each other with a substitution elasticity of 0.5 - firms can invest in more expensive equipment, more efficient in terms of energy consumption, or consume more energy products. The elasticity of substitution between different types of energy commodities is 1. For a more detailed description, see [McDougall, et al., 2007], [Burniaux, et al., 2002], and [Gohin, et al., 2003].

After preliminary analysis on the substitution elasticities for imports between different origins (ESUBM), it was decided to reduce the initial gas elasticities from 32 to 10,4[6]. For other energy products and other sectors, the ESUBM elasticities range from 4-10,4. And the elasticity of gas substitution between domestic and imported gas (ESUBD) was reduced from 16 to 5,2. For other sectors the elasticity ESUBD varies between 2–5,2.

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[6] In the 5th version of GTAP data, the elasticities for all energy products were 5.6. In consequent versions, based on [Hertel, et. al. 2007], developers of the data increased it to 34.4. However, for obtaining this elasticity it was used only 8 observations from 6 countries of FTAA and New Zealand. For crude oil the elasticity equals 10,4 which is close to the level applied to commodity goods.

3. Aggregation of countries and sectors

The classification selected for countries is shown in Table 1. Apart from EAEU countries, we select a region that includes Uzbekistan and Turkmenistan[7]. Southern Africa region includes South Africa, which accounts for 98% of the region's total emissions. Providing other countries of Southern Africa separately can make estimation process more complicated for the model, that is why we consider the whole region as part of the BRICS.

Table 1 Classification of regions in the model.

Group name	Countries included in the group
BRA	Brazil
RUS	Russia
IND	India
CHN	China, Hong Kong
SAF	Southern Africa (South Africa, Botswana, Namibia, rest of Southern Africa)
ARM	Armenia
BLR	Belarus
KAZ	Kazakhstan
KGZ	Kyrgyzstan
XSU	Uzbekistan, Turkmenistan
FSU	Former Soviet Union countries (Tajikistan etc.)
LCAM	Latin and Central America (Mexico, Argentina, Chile, Peru, etc.)
EAS	East Asia (Japan, Korea, Mongolia, the rest of the East. Asia)

[7] We added Uzbekistan, because it has a status of observer in the EAEU, and Turkmenistan that closely interacts with the EAEU countries. In the GTAP data it is labeled as Rest of Former Soviet Union (XSU).

SEAS	Southeast Asia (Brunei, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam, rest of Southeast Asia)
SAS	South Asia (Bangladesh, Nepal, Pakistan, Sri Lanka, Rest of South Asia)
WASM	West Asia (Azerbaijan, Iran, Israel, etc.) + MENA (Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, Palestine, Yemen, etc.)
EU+	EU + UK + European Free Trade Association (EFTA) countries: Iceland, Liechtenstein, Norway, Switzerland + Eastern Europe (Bulgaria, Croatia, Albania, etc.)
NAM	North America (USA, Canada)
PAC	Pacific (Australia, New Zealand etc.)
ROW	Rest of the world, East Africa, West Africa

Source: compiled by the author

Sector aggregation consists of 19 sectors: it includes 4 energy products (coal, gas, oil, petroleum products), the consumption of which leads to CO_2; 7 energy-intensive industries (chemical products, ferrous metal products, nonferrous metals, mineral products, plastic products, and other energy intensive sectors such as cellulose, pharmaceuticals etc.), electricity, food processing, agriculture, wood, textile and apparel, electronical, machinery and transport equipment, and other sectors of the economy.

4. Calculation of the regional emission reduction targets

The current section describes the commitments of the EAEU, BRICS and other countries under the Paris Agreement, based on the targets in the Nationally Determined Contributions (NDC) documents by 2030. Countries define their emission reduction goals differently: reducing net or total emissions, relative to a certain year in the past or relative to an inertial scenario without measures etc. Since the model is static, meaning that economic effects are calculated "before-after", it is necessary to choose a universal method for making assumptions about targets for all countries. First, not to complicate the scenario, we decided not to make assumptions about the future economic growth of countries, in particular the dynamics of investments and other factors of production. Secondly, official country documents or analytical reports provide information on how countries assess the emissions projections, in which countries do not take measures to reduce emissions, or in which countries apply stated policies, if countries implement it[8]. All targets are calculated as percentage decline from these projections to their NDC targets by 2030. The initial model is calibrated based on data by 2014, in the GTAP model it is assumed that initial carbon tax equals 0. However, in some countries carbon regulation imposed before 2014 [OECD, 2016]. Nevertheless, we will assume the reduction of emissions relative to the initial state in the model.

Some countries have made more ambitious targets than others. Climate Action Tracker[9] determines whether the current target is sufficient to hold the temperature increase to 1.5 degrees, that does not cause an excessively negative impact on the environment. For many countries, this goal is not sufficient. However, in the current article we will use the goals that the countries have formulated for themselves as obligations under the Paris Agreement.

A summary of the targets is provided below (Table 2). For brevity, estimates for the EAEU and BRICS countries will be shared upon request. Estimates for Russia are presented below. To make the model calculations less computationally intensive and with sufficient accuracy[10], we keep the relative structure of the goals, but multiply them by 3/4, which can be considered as an intermediate goal before 2030.

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[8] For instance, Climate Action Tracker report projections considering stated policies and action. https://climateactiontracker.org/methodology/cat-rating-methodology/; European Environment Agency provide projections for the scenario “With existing measures” https://www.eea.europa.eu/en/datahub/datahubitem-view/4b8d94a4-aed7-4e67-a54c-0623a50f48e8

[9] Climate Action Tracker https://climateactiontracker.org/.

[10] For Armenia and Kyrgyzstan calculations for the whole target could not be obtained, because the solution did not converge, according to GEMPACK program (Dragg method and Euler

Table 2 Emission reduction targets in % for each region.

Region	Target reduction of emissions under the NDC by 2030 (Compared to the baseline scenario) (x)	Estimated scenario (x*3/4)
Brazil (BRA) [11]	16	12
Russia (RUS) [12]	14	11
India (IND) [13]	22	17
China (CHN)[14]	18	14
Southern Africa (SAF)[15]	22	17
Armenia (ARM)[16]	21	16
Belarus (BLR) [17]	15	11
Kazakhstan (KAZ) [18]	29	22
Kyrgyzstan (KGZ) [19]	16	11

method of optimization). Further you will see that for these countries the contribution of total emissions is smaller and an equilibrium carbon tax in the first scenario is higher than in other economies.

[11] ICAT Brazil Project (2019): https://climateactiontransparency.org/wp-content/uploads/2022/04/Deliverable-3_Brazil-Final-Report.pdf

[12] Government of the Russian Federation (2021): Long-term development strategy of the Russian Federation with low greenhouse gas emissions until 2050.

[13] Centre for Science and Environment. 2021. India's enhanced climate targets and commitments.

[14] Wang X. et al. Pursuing an Innovative Development Pathway: Understanding China's NDC //Disclosure. – 2016.; International Energy Agency. 2022. CO2 emissions reductions in China, 2015-2060 by scenario: https://www.iea.org/data-and-statistics/charts/co2-emissions-reductions-in-china-2015-2060-by-scenario;

[15] NewClimate Institute et. al. (2019). Assessment of subnational and non-state climate action: https://newclimate.org/sites/default/files/2019/09/19-9117_Factsheet_SouthAfrica_Country.pdf

[16] The Ministry of Nature Protection of the Republic of Armenia. 2015. Third National Communication on Climate change.

[17] UN (2021) Nationally Determined Contribution of the Republic of Belarus to the reduction of greenhouse gas emissions by 2030.

[18] The republic of Kazakstan (2019): Forth Biennal report of the Republic of Kazakhstan to the UN framework convention on climate change.; Climate Action Tracker. 2022. https://climateactiontracker.org/countries/kazakhstan/

[19] The Kyrgyz Republic. 2021. Updated Nationally Determined Contribution.

Uzbekistan, Turkmenistan (XSU) [20] [21]	11	8
Other FSU countries (FSU) [22]	8	6
Latin and Central America [23] [24] [25](LCAM)	25	19
East Asia (EAS) [26] [27]	32	24
Southeast Asia (SEAS) [28] [29] [30]	24	18
South Asia (SAS) [31]	12	9

[20] Center of Hydrometeorological Service of the Republic of Uzbekistan. 2021. First Biennal Update Report of the Republic of Uzbekistan.

[21] The Government of Turkmenistan. 2022. Nationally Determined Contribution of Turkmenistan under the Paris Agreement.

[22] United Nations Development Programme 2020. Projections of GHG emissions to 2030 in Tajikistan

[23] Climate Action Tracker. 2022. Mexico https://climateactiontracker.org/countries/mexico/

[24] The Grantham Research Institute on Climate Change and the Environment (2023): https://www.climate-laws.org/geographies/venezuela/climate_targets/Economy-wide

[25] Lallana F. et al. Exploring deep decarbonization pathways for Argentina //Energy Strategy Reviews. – 2021. – T. 36. – C. 100670.

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[27] Government of the Republic of Korea, 2021. The Republic of Korea's Enhanced Update of its First Nationally Determined Contribution.

[28] University Teknologi, Malaysia; Kyoto University, Japan; National Institute for Environmental Studies, Japan (2013). Malaysia 2030: Low Carbon Society Scenarios: https://2050.nies.go.jp/report/file/lcs_asia/Malaysia.pdf

[29] World Resources Institute, 2021. Statement: Indonesia Submits New 2030 Climate Targets and First Long-Term Climate Strategy https://www.wri.org/news/statement-indonesia-submits-new-2030-climate-targets-and-first-long-term-climate-strategy

[30] Ministry of Natural Resources and Environment of the Kingdom of Thailand , 2021. Thailand: Mid-century, Long-term Low Greenhouse Gas Emission Development Strategy. https://unfccc.int/sites/default/files/resource/Thailand_LTS1.pdf

[31] UNFCC. 2021. Updated NDC for Pakistan https://unfccc.int/sites/default/files/NDC/2022-06/Pakistan%20Updated%20NDC%202021.pdf ; 2021. NDC for Bangladesh https://unfccc.int/sites/default/files/NDC/2022-06/NDC_submission_20210826revised.pdf

West Asia and MENA (WASM) [32] [33] [34] [35]	16	12
EU, UK, EFTA, Eastern Europe (EU+)[36]	20	15
North America (NAM)[37]	28	21
Australia and New Zealand (PAC)[38]	22	17

Source: compiled by the author based on the documents listed in the footnotes.

We provide an example of calculating emission reduction targets for Russia. Russia chooses a 30% reduction in emissions to the 1990 level as a target, considering[39]. For Russia the baseline scenario assumes a reduction in emissions by 2030 to 67% of the 1990 level (2077 vs 3100 MT CO2-eq). The scenario without support measures assumes 76% of emissions from 1990 levels, while the intensive scenario assumes 64% of 1990 levels. The deviation of different scenarios from the scenario without support measures varies in the range of 12-16% in 2030, the average target is 14%.

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[32] Egypt's First Updated Nationally Determined Contributions (2022): https://unfccc.int/sites/default/files/NDC/2022-07/Egypt%20Updated%20NDC.pdf.pdf
[33] Climate Transparency Report (2021). Comparing G20 Climate Action Towards Net Zero: https://www.climate-transparency.org/wp-content/uploads/2021/10/CT2021Turkey.pdf
[34] Climate Action Tracker (2021). Saudi Arabia: country summary: https://climateactiontracker.org/countries/saudi-arabia/policies-action/
[35] Climate Action Tracker (2021). Iran: country summary: https://climateactiontracker.org/countries/iran/
[36] European Environment Agency. 2023. Member States' greenhouse gas emission projections: https://www.eea.europa.eu/data-and-maps/data/greenhouse-gas-emission-projections-for-9
[37] Congressional Research Service (2017). U.S. Carbon Dioxide Emissions Trends and Projections: Role of the Clean Power Plan and Other Factors: https://crsreports.congress.gov/product/pdf/R/R44451
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[39] Government of the Russian Federation. 2021. Long-term development strategy of the Russian Federation with low greenhouse gas emissions until 2050.

5. Descriptive statistics of energy balance and CO_2 emissions by country

Based on statistical data on annual emissions in the EAEU and BRICS countries in 2021, China accounts for a significant share of the total emissions of the selected countries (65.4%), followed by India (15.7%) and Russia (10.1%) (Table 3).

Table 3 Annual carbon emissions in 2021.

Country	CO_2 million tons	Structure of emissions among selected countries, %
Armenia (ARM)	7	0.04
Belarus (BLR)	61	0.4
Russia (RUS)	1724	10
Kazakhstan (KAZ)	287	2
Kyrgyzstan (KGZ)	9	0.1
Uzbekistan, Turkmenistan (UZB+TKM)	199	1
Brazil (BRA)	482	3
China (CHN)	11107	65
India (IND)	2668	16
South Africa (SAF)	451	3

Source: Our World in Data [40]

The distribution of electricity production by source based on the country statistics for 2020 year is in Table 4. First, more than 80% of electricity is generated by fuel-fired power plants in Belarus, Kazakhstan, Uzbekistan, Turkmenistan, and South Africa. Among them, in Kazakhstan and South Africa, coal accounts for more

[40] Our World in Data. 2022. CO_2 and GHG Emissions. https://ourworldindata.org/co2/country/south-africa?country=ZAF~RUS~ARM~BLR~KAZ~KGZ~CHN~IND~BRA~UZB~TKM.

than 50% of emissions, according to GTAP data for 2014 (Table 5). The contribution of coal consumption to emissions is also high in China (76%) and India (65%).

Table 4 Electricity production by source in 2020, %.

Source	BLR[41]	RUS	KAZ	KGZ	ARM	TKM UZB+	CHN	BRA	IND	SAF	World (installed capacity)
Heat	86	64	80	19	50	91	58	24	71	82	59
Nuclear	10	18	0	0	11	0	2	1	2	3	5
Renew-ables	3	18	20	81	39	9	40	75	28	15	36

Source: UN data

Table 5 Distribution of energy consumption emissions by country in 2014, %.

Energy product	BLR	RUS	KAZ	KGZ	ARM	TKM UZB+	CHN	BRA	IND	SAF	World
Coal	6	18	51	50	0	4	76	8	65	80	42
Oil	0	0	1	0	0	0	0	0	0	0	1
Gas	63	55	33	6	81	80	4	18	7	2	22
Oil products	31	27	15	44	19	16	19	75	28	18	36

Source: GTAP 10 data

The volumes of imported energy products are high in Armenia, Belarus, and Kyrgyzstan. South Africa mainly consumes coal, but the share of imports is only

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41 http://energo-cis.ru/wyswyg/file/EE_SNG/%D0%91%D0%B5%D0%BB%D0%B0%D1%80%D1%83%D1%81%D1%8C1.pdf

1%[42]. China consumes a significant share of coal[43], but the share of imported coal is 15%. India (IND) consumes coal and petroleum products, with about 34% of coal and 11% of petroleum products imported (Table 6). Significant shares of energy exports are in Russia, Kazakhstan and the region that unites Uzbekistan and Turkmenistan (UZB+TKM). Brazil exports 18% of its oil production (Table 7) and ranks 11th among the world's oil exporters in 2020. In general, these economies are characterized by a heterogeneous structure of energy consumption and production.

Table 6 Share of imports in consumption, %.

	BLR	RUS	KAZ	KGZ	ARM	UZB+ TKM	CHN	BRA	IND	SAF
Coal	47	11	0	63	100	1	15	90	43	1
Oil	95	0	2	8	99	0	64	13	85	100
Gas	100	2	16	87	100	0	52	44	34	71
Oil products	1	3	13	90	100	4	6	15	11	23

Source: GTAP 10 data

Table 7 Export share in production, %.

	BLR	RUS	KAZ	KGZ	ARM	UZB+ TKM	CHN	BRA	IND	SAF
Coal	8	58	30	11	47	2	0	0	0	37
Oil	9	43	81	0	83	23	0	18	0	0
Gas	12	14	22	0	5	56	7	0	4	0
Oil products	46	31	29	8	0	24	6	8	14	11

[42] Carbon Brief: clear on climate. 2018. The Carbon Brief Profile: South Africa. https://www.carbonbrief.org/the-carbon-brief-profile-south-africa/.
[43] Energy Information Administration. 2022. https://www.eia.gov/international/analysis/country/CHN

Source: GTAP 10 data

6. Assessment of the economic effects of the carbon regulation in the BRICS and EAEU countries

We provide estimates of the effects of the carbon tax in each region separately (1) and compares it with the case when the ETS is introduced only in the EAEU countries (2) and the ETS between the BRICS and EAEU countries (3).

With ETS imposing among the EAEU countries, Russia (RUS), Belarus (BLR), Kyrgyzstan (KGZ) and Armenia (ARM) experience a smaller real GDP decline than in case of separate carbon tax, while Kazakhstan (KAZ), and Uzbekistan and Turkmenistan (UZB+TKM) experience larger fall in GDP. It means that in the second group of countries, initial costs of reducing emissions are lower than new equilibrium ETS price.

After comparing the carbon tax (1) and the ETS between the EAEU and BRICS (3), we observe that the latter policy measure leads to relatively better results for Russia (RUS), Brazil (BRA) and India (IND). While China's real GDP declines from -0.14% to 0.19%, South Africa's GDP declines from -0.22% to -0.23% respectively (Table 8). It means that China and South Africa in case of the ETS reduce their emissions even more than the target and receive revenue from selling the released emission allowances to other countries. Lower initial abatement costs in the first scenario can partly be explained by the significant contribution of coal to the emissions in these countries. The decrease is also observed in Uzbekistan and Turkmenistan (UZB+TKM): from -0.22% to -0.33%. At the same time, Belarus, Kyrgyzstan, Kazakhstan, and Armenia experience a smaller decline in real GDP compared to the carbon tax scenario. Sensitivity analysis shows that if we vary emission targets by 20% from the initial values, standard deviation for estimations of real GDP changes will vary from 0 (Brazil) to 0.03% (Uzbekistan and Turkmenistan).

Table 8 Change in real GDP for different scenarios.

	(1) Separate Carbon Tax		(2) EAEU ETS		(3) BRICS + EAEU ETS	
	Change, %	Change, US $ million	Change, %	Change, US $ million	Change, %	Change, US $ million
BRA	-0.20	-4746	-0.20	-4761	-0.02	-596
CHN	-0.14	-14957	-0.14	-15006	**-0.19**	**-20124**
IND	-0.09	-1801	-0.09	-1822	-0.01	-247
SAF	-0.22	-820	-0.22	-821	**-0.23**	**-873**
RUS	-0.59	-11969	-0.50	-10249	-0.40	-8088
ARM	-1.17	-136	-0.05	-6	0.08	10
BLR	-0.42	-318	-0.07	-52	0.02	14
KAZ	-0.38	-866	**-0.50**	**-1142**	-0.31	-696
KGZ	-0.66	-49	-0.29	-22	-0.14	-11
UZB+TKM	-0.22	-230	**-0.64**	**-683**	**-0.33**	**-351**

Source: author's calculations. In bold we highlighted countries that experience a larger decline in GDP relative to the 1st scenario.

The nominal tax in the case of an emission trading system between the EAEU countries is set at 28 $ USD 2014/tone CO_2. Under the ETS between the EAEU and BRICS countries, the nominal tax is equal to 16 US $ per tone CO_2. Table 9 contains information on the carbon tax for the case of separate taxation for each country and ETSs, as well as the net revenue from trading emission allowances in the case of ETSs.

Countries where real GDP declines more, face an increase in level of the carbon price. This increase ranges from 4% (China) to 41% (Uzbekistan and Turkmenistan), but the carbon tax reduction ranges from -22% (Kazakhstan) to -89% (Armenia). Thus, the logic that small economies benefit from trade with large economies is also valid here – large economies experience relatively small changes in real GDP, while most of the small economies benefit significantly (Armenia, Belarus, Kyrgyzstan). Countries that face an increase in carbon price after joining ETS, reduce their emissions even more, sell released carbon allowances and earn a positive net income. This analysis identifies which countries can reduce their emissions relatively cheaper.

Table 9 Change in real carbon tax and net income from emissions trading.

	Nominal Carbon price under Separate Carbon Tax (1)	Nominal Carbon price under EAEU ETS (2)	Net trading revenue from EAEU ETS, $ USD million	Nominal Carbon price under BRICS+EAEU ETS (3)	Net trading revenue from EAEU + BRICS ETS, $ USD million
BRA	72	72	0	16	-663
CHN	13	13	0	**16**	**3302**
IND	22	22	0	16	-1268
SAF	15	15	0	**16**	**38**
RUS	34	28	-689	16	-1275
ARM	143	28	-22	16	-15
BLR	62	28	-107	16	-86
KAZ	20	**28**	**311**	16	-126
KGZ	53	28	-11	16	-9
UZB+ TKM	11	**28**	**518**	**16**	**101**

Source: author's calculations. In bold we highlighted countries that become sellers of carbon allowances under ETSs.

Changes in real output by sector are shown in the Table 10. In Russia, we see a decline in coal, oil production, electricity. The largest increase in real output is observed in the chemical industry, ferrous and non-ferrous metals. Direction of the results remain stable even if Russia alone raises its emissions reduction target from 11% to 16%.

Joint potential comparative advantages include chemical industry for Belarus, Russia, Kazakhstan, Brazil, India. Nonferrous metals increase production in Russia, Kazakhstan, South Africa, Uzbekistan and Turkmenistan, Armenia. Ferrous metals increase mostly in Russia, China, Brazil, South Africa, Armenia. All these industries are energy intensive. The fact that its production increases means that, firstly, some countries decrease their emissions at the expense of reduction of energy products. Secondly, in some countries these industries have comparatively lower carbon intensities compared to other countries. For instance, Russian company Rusal's plants are located close to hydroelectricity, which ensures low carbon intensity of the production. Belarus has lower emission intensities in chemical industry. The model shows that in the medium-term the geographical structure of production adjusts so that countries manage to fulfill emission reduction targets. Interestingly, among chosen countries only in Russia and Kazakhstan, there is an increase in output of machinery, transport, and electronical equipment sectors, though to a less extent. For Russia an increase in machinery and transport equipment makes up 1416 mln US $, in electronical equipment 1354 mln US $. For Kazakhstan 165 mln US $ and 195 mln US $ respectively.

Table 10 Highest increase and decrease in the sectoral production under the ETS BRICS+EAEU, mln US $.

	Industries mostly increase			*Industries mostly decrease*		
Brazil	**Chemicals**	**Ferrous metals**	Other energy intensive ind.	Oil	Other indistries and sevices	Composite of capital
	1998	1287	468	-3303	-2923	-1542
China	**Ferrous metals**	Agriculture	Mineral products	Coal	Electricity	Other industries and services
	473	413	364	-41449	-37638	-31255

India	Oil products	**Chemicals**	Textile and apparel	Electricity	Coal	Machinery and transport equipment
	2027	1603	426	-10165	-8480	-3148
Russia	**Chemicals**	**Nonferrous metals**	**Ferrous metals**	Electricity	Composite of capital good	Oil
	5665	4142	3716	-5981	-5621	-4237
South Africa	**Ferrous metals**	**Nonferrous metals**	Food industry	Electricity	Coal	Other energy intensive ind.
	415	338	108	-3088	-2945	-912
Armenia	Electricity	**Ferrous metals**	**Nonferrous metals**	Other industries and services	Composite of capital good	Food industry
	27	7	6	-26	-23	-6
Belarus	Electricity	**Chemicals**	Composite of capital good	Food industry	Machinery and transport equip.	Electrical equipment
	263	193	137	-175	-148	-136
Kazakh-stan	**Nonferrous metals**	Other energy intensive products	**Chemicals**	Gas	Oil	Electricity
	1062	545	521	-2009	-1453	-1265
Kyrgyzs-tan	Electricity			Nonferrous metals	Mineral products	Food industry
	15			-27	-19	-18
Uzbekistan and Turkmenistan	**Nonferrous metals**	Gas		Other industries and services	Electricity	Composite of capital good
	245	16		-700	-516	-466

Source: author's calculations. In bold we highlighted sectors that increase production mostly in several countries at the same time.

For Russia, the transition from energy products to energy-intensive goods is also observed in real exports. Exports of energy products are also declining, but exports of energy-intensive goods, such as chemical products, ferrous metals, and non-ferrous metals, are increasing (Table 11). For Kazakhstan, the model predicts an increase in real exports and real output in the chemical industry, non-ferrous metals. The main export losses are observed in the oil and gas sector. This rather large drop is compensated by an increase in imports of gas from the region of Uzbekistan and Turkmenistan. Interestingly in Kazakhstan, that decline in the gas sector is larger than in coal sector. This is partly because according to GTAP data, in Kazakhstan, the intensities of gas and coal emissions for several industries are comparable. This point requires further research. In China exports increases for ferrous metals, mineral products, and food industry. For brevity, we do not look at all countries in detail, but provide a summary of changes in real industrial production Table 10, and information on exports in millions of US dollars 2014 Table 11.

Table 11 Change in real sector exports for countries in the case of ETS BRICS+EAEU, mln US $ 2014.

	Industries mostly increase			Industries mostly decrease		
Brazil	**Ferrous metals**	**Chemicals**	Other energy intensive products	Oil	Other industries and services	Food industry
	1059	729	243	-2605	-350	-321
China	**Ferrous metals**	Mineral products	Food industry	Electrical equipment	Machinery and transport equip.	Oil products
	4722	1844	358	-9418	-4597	-2785
India	**Chemicals**	Other industries and services	Textile and apparel	Machinery and transport equip.	Ferrous metals	Nonferrous metals
	990	719	227	-1416	-929	-820

Russia	**Chemicals**	Other industries and services	**Nonferrous metals**	Oil	Gas	Coal
	3939	3318	2657	-7807	-4839	-2692
South Africa	**Nonferrous metals**	**Ferrous metals**	Other industries and services	Other energy intensive products	Coal	Electricity
	413	348	174	-700	-550	-413
Armenia	Electricity	**Nonferrous metals**	**Ferrous metals**	Other industries and services	Food industry	Other energy intensive products
	38	8	4	-21	-11	-6
Belarus	Electricity	**Chemicals**	**Ferrous metals**	Food industry	Other industries and services	Machinery and transport equip.
	198	156	58	-180	-168	-96
Kazakhstan	**Nonferrous metals**	Other industries and services	**Chemicals**	Oil	Gas	Ferrous metals
	913	509	433	-1554	-591	-319
Kyrgyzstan	Electricity			Other industries and services	Agriculture	Nonferrous metals
	2			-49	-13	-11
Uzbekistan and Turkmenistan	Gas	**Nonferrous metals**		Oil	Chemicals	Oil products
	604	223		-322	-209	-94

Source: author's calculations. In bold we highlighted sectors that increase exports mostly in several countries at the same time.

In the Table 12 there are changes prices for energy products and electricity. For all countries, domestic energy prices grow to a lesser extent in case of ETS, except the countries, that initially had relatively lower costs (carbon tax) to reduce emissions - China, Uzbekistan and Turkmenistan, and South Africa. In almost all countries, the price of gas increases less than for coal, but for Kazakhstan the situation is the opposite – for many industries, the intensity of gas emissions is higher than for coal. Price for electricity under Carbon tax scenario varies from 1.5% (Kyrgyzstan) to 40.4% (Armenia), while in case of ETS it varies from 0.6% (Kyrgyzstan) to 21.3% (South Africa).

Table 12 Real change in domestic energy prices, %

(1) Separate carbon tax	BLR	RUS	KAZ	KGZ	ARM	TKM UZB+	CHN	BRA	IND	SAF
Coal	46.9	43.1	43.5	68.7	107.1	35.4	33.3	54.8	40.7	34.9
Oil	-7.2	-2.3	-0.4	-7.1	6.6	-2.7	-3.2	-3.5	-3.8	-3.9
Gas	12.3	13.5	61.2	65.7	29.4	26.2	20.0	26.6	5.3	2.3
Oil products	1.4	2.1	4.7	4.6	20.2	1.7	1.4	8.9	0.0	1.9
Electricity	9.2	11.9	18.2	1.5	40.4	12.7	11.9	6.1	7.7	17.2
(2) ETS BRICS+ EAEU	BLR	RUS	KAZ	KGZ	ARM	TKM UZB+	CHN	BRA	IND	SAF
Coal	13.9	25.8	31.7	18.5	11.2	38.4	34.3	13.1	32.4	43.9
Oil	-4.8	-1.9	-0.6	-3.2	-1.6	-2.7	-2.9	-2.4	-3.4	-3.5
Gas	1.8	8.0	45.3	23.0	1.5	28.4	20.6	6.5	4.2	3.4
Oil products	-2.0	0.9	3.2	-0.8	0.1	2.1	1.7	1.1	-0.3	3.3
Electricity	1.5	7.2	13.5	0.6	3.0	13.4	12.3	2.0	6.2	21.3

Source: author's calculations. Real change in energy prices means that this change is adjusted to the change in average prices in the economies.

In terms of real returns on capital and labor, China, South Africa, Uzbekistan, and Turkmenistan experience slightly more reductions under ETS compared to a separate carbon tax. But differences between two scenarios mainly vary between 0-0.2%. The exception is the capital in South Africa that lose in the return from -1.8% to -2.4%.

Changes in the rate of return on capital coincides with the direction of change in real GDP. For buyers of allowances declines are smaller under ETS, while for sellers of carbon allowances (China, South Africa, Turkmenistan and Uzbekistan) decline in rate of return is more under the ETS. Interestingly, in Kyrgyzstan return on capital positive in both cases, the electricity sector mainly increases the demand for capital. Positive return on land[1] in Russia (-2.0-2.6%) and Kazakhstan (3.8-4.7%) explained by increased demand for energy intensive products (metals, chemicals etc.) and electricity.

In the context of income inequality, in India the decline in wages of unskilled labor is greater than the decline in the return of skilled labor force, and joining the ETS slightly reduces this negative effect for both groups. A similar trend is observed in Belarus. In Russia and Kazakhstan, the reduction in wages of skilled labor is higher than of unskilled labor since skilled labor (technical workers) is involved in the energy sectors.

Table 13 Change in return on labor and capital, %

(1) Separate Carbon tax	BLR	RUS	KAZ	KGZ	ARM	UZB+ TKM	CHN	BRA	IND	SAF
Unskilled labor	-1.2	-1.4	-1.1	**2.5**	-1.0	-0.7	-0.6	-0.4	-0.6	-0.6
Skilled labor	-0.6	-1.8	-1.6	**5.6**	-1.2	-0.4	-0.7	-0.5	-0.2	-0.6
Capital	-3.5	-3.3	-3.0	**0.6**	-5.7	-2.7	-1.6	-1.6	-1.9	-1.8

(2) ETS BRICS+EAEU	BLR	RUS	KAZ	KGZ	ARM	TKM UZB+	CHN	BRA	IND	SAF
Unskilled labor	**0.1**	-0.8	-0.8	**0.9**	0.0	-0.8	-0.6	-0.1	-0.5	-0.8
Skilled labor	**0.3**	-1.3	-1.3	**1.9**	0.0	-0.4	-0.7	-0.1	-0.1	-0.8
Capital	0.0	-2.1	-2.3	**0.8**	-0.4	-2.9	-1.7	-0.4	-1.5	-2.4

Source: author's calculations

Terms of trade are declining for Russia, Kazakhstan, Uzbekistan and Turkmenistan, and Brazil in both scenarios (Table 14). Among these countries, only Brazil's terms of trade decline to a greater extent in the case of ETS. This change in the terms of trade in Brazil is more due to changes in export prices. For China, India, South Africa, Belarus, Kyrgyzstan, Armenia, changes in the terms of trade in all cases are positive and the change is slightly higher in the case of carbon taxation.

Table 14 Changes in terms of trade, %

	(1) Separate Carbon Tax	(2) EAEU ETS	(3) BRICS + EAEU ETS
BRA	**-0.03**	**-0.03**	**-0.24**
CHN	0.31	0.31	0.29
IND	0.61	0.61	0.52
SAF	0.57	0.56	0.56
RUS	**-2.79**	**-2.73**	**-2.58**
ARM	2.64	0.83	0.66
BLR	2.46	1.36	1.06
KAZ	**-3.14**	**-3.07**	**-2.83**
KGZ	4.79	2.45	1.73
UZB+TKM	**-0.28**	**-0.17**	**-0.14**

Source: author's calculations

World FOB export price indexes for electricity increase (4.0–4.4%), for energy-intensive goods such as mineral products, non-ferrous and ferrous metals, chemical industry export prices are also growing, they vary between 0.2%–2.8% among studied countries that export it. Since it becomes more expensive to produce them, specialization in these industries remains only in those countries that can reduce emissions at the expense of energy industries (gas, oil, coal), or already have relatively low emission intensities compared to other countries. A FOB price decrease for oil, gas and coal varies from -0.6% to -2.0%. For brevity, we do not report table with results for all industries.

7. Current renewable energy initiatives in the BRICS and EAEU countries

China is one of the largest investors in developing low-carbon technologies, solar and wind energy[44]. China provides FDI projects in Uzbekistan, South Africa, southern regions of Russia and other countries. According to analytical estimates, Uzbekistan is developing the use of solar energy due to its comparative advantage in climate conditions[45] [46]. Uzbekistan has awarded contracts with China to build solar farms with energy capacity of 4 GW[47] (14% of planned generating capacity by 2030[48]).

The IEA report[49] states that one of the goals of the South Africa is to increase energy generation from natural gas and renewable energy sources by at least 20 GW

[44] World economic forum. 2023. "Spending on low-carbon energy technology is on the brink of overtaking fossil fuels. These 4 charts tell the full story.". https://www.weforum.org/agenda/2023/02/low-carbon-investment-record-2022/.

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[47] Investment monitor. 2023. Chinese companies invest in Uzbekistan solar farms: https://www.investmentmonitor.ai/news/chinese-companies-invest-in-uzbekistan-solar-farms/?cf-view

[48] https://www.iea.org/reports/uzbekistan-energy-profile/energy-security

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and decommission 35 GW of coal-fired power plants by 2030. In 2023 China offered to provide the South African grid with 66GW of solar infrastructure[50].

Concerning Russian initiatives, in 2022 the experimental trading system in Sakhalin was launched[51]. This experience is planned to be scaled up in the future. Kazakhstan and Russia developed criteria for financing green projects[52].

In practice, the introduction of renewable energy sources requires cross-country cooperation. For example, if countries have access to the same river and one country installs a hydroelectric power station upstream, this may lead to water access and affect the agricultural sector of another country, as in the case of Kyrgyzstan, Kazakhstan, and Uzbekistan[53]. Another problem is instability of renewable energy sources due to changes in weather conditions. That is why diversification of energy sources serves as a solution to the problem of energy security. As an example, Russia is involved in the construction of nuclear power plants in Kyrgyzstan, Brazil, Turkey, and other countries. Considering the comparative advantages in available energy sources, technologies and climate, international investment projects can solve the problems of energy supply stability [54] .

Conclusion and policy implications

The study compares the economic effects of a national carbon tax within countries and a joint carbon trading system in the EAEU and BRICS countries in the

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[50] PV Tech. 2023. China offers 66GW of solar infrastructure to South Africa: https://www.pv-tech.org/china-offers-66gw-of-solar-infrastructure-to-south-africa/

[51] Ecosphere. The Sakhalin Experiment: Creating the World's First Zero Emissions Region. [Rus]- 31 October 2022 г.. - https://ecosphere.press/2022/10/31/sahalinskij-eksperiment-kak-sozdaetsya-pervyj-v-mire-region-nulevyh-vybrosov/.

[52] Eurasion economic comission Criteria of green projects of the Eurasian Economic Union member states [Rus] // Eurasion economic comission. - 2023. - https://eec.eaeunion.org/upload/medialibrary/df7/Kriterii-dlya-opublikovaniya-_Modelnaya-taksonomiya_.pdf.

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[54] World nuclear news Brazil's ENBPar and Rosatom agree to cooperate [Online]. - 2022. - https://www.world-nuclear-news.org/Articles/Brazils-ENBPar-and-Rosatom-agree-to-cooperate.

medium term. The emission targets are equal to 3/4 of their targets according to the NDC documents by 2030.

The model shows that in China, South Africa, and Uzbekistan and Turkmenistan, real GDP declines more with ETS policy, than with a national tax, as these countries have relatively lower abatement costs. They reduce emissions to a greater extent than it is prescribed by their targets and generate positive net revenue from the sale of emission permits to other countries. This is partly because China and South Africa have a significant share of coal in their energy balance, according to the GTAP data. For other countries the ETS is preferred to national taxation in terms of its effect on real GDP.

The analysis shows which sectors can gain new comparative advantages in the context of declining global demand for traditional energy resources. For example, for Russia, Belarus, Kazakhstan, Brazil, and India the export of chemical products is increasing. Also, in Kazakhstan, Russia, Armenia, Uzbekistan and Turkmenistan, South Africa, export growth is observed non-ferrous metals. In South Africa, Brazil, China, Amenia there is an increase in exports and output of ferrous metals. Exports of the chemical industry and non-ferrous and ferrous metals may seem counterintuitive as these industries are energy intensive. However, non-ferrous metals in Russia have rather low emission intensities compared to other countries. The second reason is that some of the countries specialize in exporting energy resources. Simulations show that CO_2 emissions of these countries are reduced at the expense of energy sectors, while the released factors of production are transferred to energy-intensive industries.

These industries can become new comparative advantages of the EAEU and BRICS countries. However, to maintain these comparative advantages in the long term, countries need to cooperate for developing sector-specific technologies to make the production process more sustainable [Bashmakov, et al., 2022].

In [Volchkova, et al., 2016], it was revealed that the chemical industry, machinery and equipment, and the textile industry can become joint potential comparative advantages for EAEU countries. According to the results of the current study, in Russia and Kazakhstan, the chemical industry and to a lesser extent machinery and equipment sector increase output, that is, these industries remain stable to the carbon regulation. The results of the model coincide with the current proposals of the EAEU countries for joint economic development: Kazakhstan considers the production of electric vehicles, mainline locomotives, agricultural and passenger vehicles, construction materials and chemical products, as well as the development of deposits of non-ferrous and ferrous metals as priority areas, as follows from the Eurasian Economic Forum 2023 [55].

The model does not include renewables sector explicitly and foreign direct investments. However, according to statistics, China invests in solar power industries in Uzbekistan, South Africa, and other countries. If the projects are scaled up, countries can reduce their emissions with lower production losses than the model predicts.

The next step of the analysis is to apply the GTAP-E-Power model that contains data on the renewable energy sectors. Another aspect that was not considered is the sanctions imposed on Russian economy in 2022. Since it is related to the export of energy and energy-intensive products, it is important to consider changes in the geography of trade flows in the further research.

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