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Ekonomicheskaya Politika, 2024, vol. 19, no. 1, pp. 66–91 DOI: 10.18288/1994-5124-2024-1-66-91

Climate Change Economics

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Abstract
The paper compares the economic effects of a national carbon tax with those of an emission trading system (ETS) between EAEU and BRICS countries over the medium term. Also included are Uzbekistan, which has observer status in the EAEU, and Turkmenistan, which is an EAEU trade and economic partner. The static computable general equilibrium model GTAP-E is employed. Targets for reducing emissions are formulated on the basis of the countries' intermediate goals as stated in their respective submissions under the Paris Agreement. The resulting simulations show that, in terms of real GDP, an emission trading scheme would be more favorable than national taxation for countries such as Brazil, India, Russia, Armenia, Belarus, Kazakhstan, and Kyrgyzstan. However, for China, South Africa, Uzbekistan and Turkmenistan, resorting to an ETS would produce a comparatively greater reduction in GDP. Because the second group of countries has lower abatement costs than the equilibrium carbon price under an ETS, that scenario would permit those countries to reduce emissions by a greater amount and sell emission allowances. The analysis also shows which sectors would increase production after carbon regulation. A considerable increase in production and exports would occur for chemicals and for ferrous and nonferrous metals in several BRICS and EAEU countries. Although those industries are energy-intensive, the countries concerned could decrease emissions by reducing production in the energy or other sectors. These industries could benefit from potential joint comparative advantages in the context of declining demand for traditional energy sources. These findings should be valuable in devising integration policy.
Keywords: computable general equilibrium model, carbon regulation, CO_2 emissions, BRICS, EAEU, integration policy.
JEL: D58, F11, Q43, Q48, Q56.

Acknowledgements
For their help and useful comments on this paper the author would like to thank Natalia Shagas; Natalya Volchkova; Alexander Knobel; Alexander Firanchuk; Natalia Turdyeva; Vladimir Sedalischev; Ivan Savin; the organizing committee and participants at "Green Economy — Different Countries' Approaches" section of the 24th Yasin Conference; the 7th Annual Scientific Conference of the Consortium of Journals Faculty of Economics Lomonosov MSU "Economic Development in BRICS+ Countries" session; and the "Scientific Start" Project of the Faculty of Economics at Lomonosov MSU.

Introduction

Many countries are currently developing national climate policies and cooperating with each other 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, thirty-nine national jurisdictions have a carbon tax or emissions trading system.[1] It is an empirical fact that energy and energy-intensive products are among the most frequently traded goods [Copeland et al., 2021]. Cooperation between countries in order to reduce emissions is important for two reasons. First, to avoid import tariffs that depend upon the carbon intensity of products, it is necessary to develop mutually accepted carbon regulation between trading partners. Second, an international ETS facilitates the common goal of reducing emissions with minimal economic loss, as a common market makes the abatement mechanism more flexible.

BRICS countries form a group that is striving to stimulate trade and investment, including in the energy sector.[2] The EAEU is an economic union between Armenia, Belarus, Kazakhstan, Kyrgyzstan, and Russia that was established in 2015. The EAEU countries have close trade relations with China, India, and other BRICS countries. Kazakhstan[3] and Belarus[4] officially announced their application for BRICS membership in 2023. This study is aimed at analyzing the potential for joint efforts by the EAEU and BRICS countries in formulating carbon taxation policy.

This paper employs the computable general equilibrium model GTAP-E to compare the economic effects of implementing an emissions trading system between the EAEU and BRICS countries with the effects of imposing a carbon tax independently in each country. The percentage reductions in emissions in the two scenarios are assumed to be two thirds of the ultimate 2030 targets set by the countries' official documents (NDCs) under the Paris Agreement and may be considered an intermediate goal to be achieved at some point before 2030. The article assesses the impact of such a reduction on real GDP, production, trade flows, factors of production, prices, and terms of trade. This analysis also helps to identify countries with lower relative abatement

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[1] Carbon Pricing Dashboard. https://carbonpricingdashboard.worldbank.org/map_data.

[2] 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.

[3] Announcement by the President of Kazakhstan K.-J. Tokaev at a Meeting of the Dialogue of Heads of State in the BRICS Plus Format. 24 August 2023. https://tass.ru/mezhdunarodnaya-panorama/18578423. (In Russ.)

[4] Statement by the Minister of Foreign Affairs of Belarus Sergei Aleinik at the BRICS Outreach and BRICS Plus Dialogues (24 August 2023, Johannesburg). https://mfa.gov.by/en/press/statements/b81aa8d4-a1b18810.html.

costs. Changes in sectoral production in the context of declining global demand for traditional energy resources are also examined.

1. Current Approaches in Research That Analyzes Carbon Regulation Using Computable General Equilibrium Models

Simulation models are employed to assess the impact of carbon taxation on national economies. For example, the IMF [Parry et al., 2022] calculates the additional benefits of reducing emissions from decreased population mortality due to environmental pollution. Enhanced growth from such benefits for Russia come to approximately 2% of real GDP, while the increase for China is ~1.4% and for India ~0.3% etc. After introducing carbon taxation countries will inevitably experience declining production. However, if they do not take any countervailing measures, they may be exposed to economic losses from climate change. William Nordhaus [Nordhaus, 2006] finds that, the negative impact on economic activity will be from 0.9 to 3.0% of global output if the average earth temperature rises by 3°C.

The free rider problem is one reason why carbon regulation has been introduced unevenly across countries. To offset it, Nordhaus [Nordhaus, 2015] proposes creating climate clubs — introduction of a carbon tax among the countries that are participants in the club coupled with import tariffs on all goods imported from non-participants. This provides incentives for countries to engage in joint carbon regulation without concerns about carbon leakage. In order to concentrate on the further development of BRICS and EAEU economies as the demand for traditional energy products declines, this paper proceeds on the assumption that all countries set emission targets and introduce carbon regulation simultaneously.

The literature includes several articles that explore carbon regulation for the EU [Cunha Montenegro et al., 2019; Fragkos et al., 2017]. There are also examples of ETS modeling [Nong, Siriwardana, 2017] among countries that have already instituted national carbon emission regulation: 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 an international ETS. As a result, Kazakhstan would become a seller of emission allowances, and the EU a buyer of them.

Some studies have modelled an international ETS that includes China [Zhang et al., 2017] in order to study the effect of an emissions trading system between China, the United States, Europe, Australia, and South Korea. Other authors [Ma et al., 2019] evaluate the effect of an ETS between China, Japan, and South Korea. Mahinda Siriwardana and Duy Nong [Siriwardana, Nong, 2018] consider cross-country regulation for Australia, the USA, the EU, India, China, and other countries. In most of the studies China initially has lower abatement costs and therefore becomes a seller of carbon allowances under an emission trading system.

Some papers have investigated large emitters of emissions [Thierfelder et al., 2021]. Based on Global Trade Analysis Project (GTAP) 10 data, those researchers analyzed emissions for groups of countries including Russia, China, India, South Africa, and other regions. They compared the effects of an energy consumption tax and a carbon tax using a GLOBE-EN model. A carbon tax turned out to be more effective because, all other things being equal, it causes a smaller reduction in a country's GDP. With a global emission target of 20%, the largest GDP declines would occur in China, South Africa, and Russia (from approximately –0.2 to –0.5%).

Several studies examine a single country. Nong [Nong, 2020] uses the GTAP-E-Powers model to study the economy of South Africa. There are a number of examinations of the Chinese economy [Mu et al., 2018; Xu et al., 2023] and Kazakhstan's economy [Kapsalyamova et al., 2019].

Other research analyzes the energy transition in Russia. One research team [Makarov et al., 2020] used the Emissions Prediction and Policy Analysis model from MIT to estimate what effect a decrease in external demand for Russian energy products would have on Russia's GDP. The results indicate 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 a practical recommendation, the authors suggest redirecting investments to the manufacturing, service, agriculture, and food processing sectors. Using the same model, Sergey Paltsev and Elena Kalinina [Paltsev, Kalinina, 2014] calculated the effect on the Russian economy of introducing a carbon tax in all regions simultaneously (to reach USD 160 per ton CO_2 by 2050). The conclusion was that GDP might fall by 10 to 20% compared to a baseline scenario without offsetting measures because of lower external demand for energy from traditional sources and the high cost of implementing renewable energy sources. Other researchers [Böhringer et al., 2015] examine the environmental impact of Russia's accession to the WTO using a CGE model which considers imperfect competition. They compare three policies for CO_2 reduction: emission trading, emission intensity standards, and energy efficiency standards. An emission trading system turned out to be preferable to the other measures in terms of minimizing welfare costs.

In sum, the literature contains studies concentrating on:

1) individual countries in order to study the impact on various sectors of their economies [Böhringer et al., 2015; Nong, 2020; Xu et al., 2023];

2) highly aggregated regions or major carbon emitters [Siriwardana, Nong, 2018; Thierfelder et al., 2021; Zhang et al., 2017];
3) countries where some type of carbon emission regulation is already in place [Ma et al., 2019; Nong, Siriwardana, 2017].

However, no assessment of joint carbon regulation in the EAEU and BRICS countries, is evident in the literature. In addition to addressing that gap, this paper also examines which industries have the potential to provide comparative advantages to these countries. According to Natalya Volchkova and coauthors [Volchkova et al., 2016] who based their conclusion on the Hausmann-Klinger method, joint comparative advantages for EAEU countries could come about in the chemical industry, machinery and equipment production, and the textile industry. Results of this kind can contribute to the literature on the development of integration processes [Knobel, Chokaev, 2014; Knobel, Sedalishchev, 2017].

2. Description of the Model and GTAP 10 Data

The model has been calibrated in keeping with the tenth version GTAP data from 2014, which has been 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 seventh version of the GTAP [Turdyeva, Shkrebela, 2009]. The database was derived from the input-output tables of 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 Thomas Hertel and coauthors [Hertel et al., 2007]. Macroeconomic data on GDP, private and public consumption, investment, trade flows, and taxes are based on World Bank data and 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 more detailed information, please refer to Angel Aguiar and coauthors [Aguiar et al., 2019].

Data related to the energy sector include statistics on CO_2 emissions and such parameters as elasticity of substitution for capital, energy, and various types of fuel. There are also five energy products in the model, whose consumption produces CO_2 emissions: coal, crude oil, natural gas, petroleum products, and gas. GTAP emissions data is based on data from the International Energy Agency. The initial quota amount for emissions was set equal to actual emissions and the tax at zero. In this paper, it is assumed that a tax will be imposed only on intermediate usage of energy products by production sectors, and it will apply to the intermediate usage of both domestic and imported energy products.

As in the standard computable general equilibrium GTAP model, in the GTAP-E model [McDougall, Golub, 2007] perfect competition and constant returns to scale are assumed. The model is presented in a linearized form and elaborated using GEMPACK software.[5] A detailed description of the model is presented by Robert McDougall and Alla Golub [McDougall, Golub, 2007] including information on the design of the emission trading system. In the scenarios considered, a carbon tax will be endogenously specified such that it achieves the required exogenous emission reduction.

For the current study, it is assumed that unskilled labor, skilled labor and capital are mobile between sectors, while land and natural resources are immobile, which implies that they would have a medium-term effect on the economy. Capital and labor are immobile between regions. An example of such emission trading scheme scenarios can be found in work by Jean-Marc Burniaux and Truong Truong [Burniaux, Truong, 2002]. Code incorporating closures and shocks can be found in the revised version of the GTAP-E [McDougall, Golub, 2007]. The GTAPEv8 archive contains two experiments: Kyoto without emission trading (kyonotr) and Kyoto with Annex 1 trading (kyotr).[6] With adjustments for the chosen regions and targets, these experiments are relevant for a separate carbon tax scenario and emission trading scheme scenario, respectively.

The production function has been modeled using a “top-down” approach, in which the overall structure of the economy is described and energy consumption is based on the demand generated by production sectors and households [Burniaux, Truong, 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 the primary factors of production and energy and the sub-product of intermediate goods. In keeping with 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 because capital and energy goods can be replaced by each other with a substitution elasticity of 0.5 — firms can invest in more expensive equipment that is more efficient in terms of energy consumption, or they may choose to consume more energy products. The elasticity of substitution between different types of energy commodities is 1. For a more detailed description, see the sources already mentioned [Burniaux, Truong, 2002; McDougall, Golub, 2007].

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[5] Specifically, Rungtap and related programs have been employed. For aggregation the choice was Flexagg.

[6] Code for the GTAP-E model: https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=2959

After preliminary analysis of the substitution elasticities for imports between different origins (ESUBM), it was decided to reduce the initial gas elasticities from 32.0 to 10.4.[7] For other energy products and other sectors, the ESUBM elasticities range from 4.0 to 10.4. In addition, the elasticity of gas substitution between domestic and imported gas (ESUBD) was reduced from 16 to 5.2. For other sectors the ESUBD elasticity varies from 2.0 to 5.2.

3. Aggregation of Countries and Sectors

The classification selected for countries is shown in Table 1. Apart from EAEU countries, this study examines a region that includes Uzbekistan and Turkmenistan because Uzbekistan has observer status in the EAEU and Turkmenistan interacts closely with the EAEU countries. The southern Africa region includes South Africa, which accounts for 98% of the region's total emissions. Including the other countries in southern Africa separately would have made estimation more time-consuming for the model; hence, the entire region has been considered as a part of the BRICS countries. Regions other than the BRICS and EAEU economies have been included in more aggregated groups.

Table 1

Classification of Regions in the Model

Group	Countries Included	GTAP Code
BRA	Brazil	bra
CHN	China, Hong Kong	chn, hkg
IND	India	ind
RUS	Russia	rus
SAF	Southern Africa (South Africa, Botswana, Namibia, and the remainder of the South African Customs Union)	bwa, nam, zaf, xsc
ARM	Armenia	arm
BLR	Belarus	blr
KAZ	Kazakhstan	kaz
KGZ	Kyrgyzstan	kgz
UZB + TKM	Uzbekistan, Turkmenistan	xsu
OFSU	Other countries formerly in the Soviet Union (Tajikistan, Ukraine)	tjk, ukr
LCAM	Latin and Central America (Mexico, the remainder of North America, Argentina, Bolivia, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela (Bolivarian Republic of), the remainder of South America, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, the remainder of Central America, Dominican Republic, Jamaica, Puerto Rico, Trinidad and Tobago, the remainder of the Caribbean)	mex, xna, arg, bol, chl, col, ecu, pry, per, ury, ven, xsm, cri, gtm, hnd, nic, pan, slv, xca, dom, jam, pri, tto, xcb

[7] In the fifth version of GTAP data, the elasticities for all energy products were 5.6. In subsequent versions, developers of the data increased it to 34.4 in response to additional research [Hertel et al., 2007]. However, only eight observations from six countries in the FTAA plus New Zealand were used to arrive at this elasticity. The elasticity for crude oil is 10.4, which is close to the level applied to commodity goods.

The end of the table 1

Group	Countries Included	GTAP Code
EAS	East Asia (Japan, Korea, Mongolia, Taiwan, the remainder of East Asia)	jpn, kor, mng, twn, xea
SEAS	Southeast Asia (Brunei, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam, the remainder of Southeast Asia)	brn, khm, idn, lao, mys, phl, sgp, tha, vnm, xse
SAS	South Asia (Bangladesh, Nepal, Pakistan, Sri Lanka, the remainder of South Asia)	bgd, npl, pak, lka, xsa
WASM	West Asia and MENA (Azerbaijan, Iran, Israel, Bahrain, Georgia, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Syria, Turkey, Egypt, Morocco, Tunisia, United Arab Emirates, the remainder of West Asia, the remainder of North Africa)	aze, geo, bhr, irn, isr, jor, kwt, omn, qat, sau, tur, are, xws, egy, mar, tun, xnf
EU +	EU + UK + European Free Trade Association (EFTA) countries: Iceland, Liechtenstein, Norway, Switzerland + Albania, the remainder of Eastern Europe, the remainder of Europe	aut, bel, bgr, hrv, cyp, cze, dnk, est, fin, fra, deu, grc, hun, irl, ita, lva, ltu, lux, mlt, nld, pol, prt, rou, svk, svn, esp, swe, gbr, che, nor, xef, alb, xee, xer
NAM	North America (USA, Canada)	usa, can
PAC	Pacific (Australia, New Zealand, the remainder of Oceania)	aus, nzl, xoc
ROW	East Africa, West Africa, Rest of the world	ben, bfa, cmr, civ, gha, gin, nga, sen, tgo, xwf, xcf, xac, eth, ken, mdg, mwi, mus, moz, rwa, tza, uga, zmb, zwe, xec, xtw

Source: compiled by the author based on GTAP classification. https://www.gtap.agecon.purdue.edu/databases/regions.aspx?version=10.131.

Sector aggregation comprises 19 sectors: 4 energy products (coal, gas, oil, petroleum products) whose consumption produces 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, textiles and apparel, electronics, machinery and transport equipment, and other sectors of the economy (Table 2).

Table 2

Aggregation of Sectors

Aggregated Sector	Sectors Included	GTAP Code
Electricity	Electricity	ely
Mineral products	Mineral products n. e. c. (not elsewhere classified)	nmm
Ferrous metals	Ferrous metals	i_s
Chemical products	Chemicals	chm
Nonferrous metals	Metals n. e. c.	nfm
Metal products	Metal products	fmp
Plastic products	Rubber, plastic products	rpp
Machinery and transport equipment	Machinery and equipment n. e. c., motor vehicles and parts, transport equipment n. e. c.	ome, mvh, otn

The end of the table 2

Aggregated Sector	Sectors Included	GTAP Code
Electronic equipment	Electronic equipment, electrical equipment	ele, eeq
Other energy intensive products	Minerals n. e. c., paper products, publishing, pharmaceuticals	oxt, ppp, bph
Wood	Wood products	lum
Textile and apparel	Textiles, wearing apparel, leather products	tex, wap, lea
Food industry	Bovine cattle, sheep and goat meat products, meat products, vegetable oils and fats, dairy products, processed rice, sugar, other food products n. e. c., beverages and tobacco products	cmt, omt, vol, mil, pcr, sgr, ofd, b_t
Other industries and services	Manufactures n. e. c., water, construction, trade, accommodation and food, land transport and transport via pipelines, water transport, air transport, warehousing, communication, other financial intermediation, insurance, real estate services, other business services n. e. c., recreation and other services, public admin. and defense, education, health, ownership of dwellings	wtr, cns, trd, afs, otp, wtp, atp, whs, cmn, ofi, ins, rsa, obs, ros, osg, edu, hht, dwe, omf
Agriculture (including forestry and fishing)	Rice, wheat, cereal grains n. e. c, vegetables, fruit, nuts, oil seeds, sugar cane, sugar beet, plant-based fibers, crops n.e.c, bovine cattle, sheep and goats, horses, animal products n. e. c., raw milk, wool, silk-worm cocoons, forestry, fishing	pdr, wht, gro, v_f, osd, c_b, pfb, ocr, ctl, oap, rmk, wol, frs, fsh
Oil products	Petroleum, coal products	p_c
Gas	Gas, gas manufacture, distribution	gas
Coal	Coal	coa
Oil	Oil	oil

Source: compiled by the author based on the GTAP sectors classification. https://www.gtap.agecon.purdue.edu/databases/v10/v10_sectors.aspx.

4. Calculation of the Regional Emission Reduction Targets

This section describes the commitments of the EAEU, BRICS and other countries under the Paris Agreement according to the 2030 targets in their Nationally Determined Contribution (NDC) submissions. Countries define their emission reduction goals differently: reducing net or total emissions relative to a reference point, which may be a certain year in the past, or an inertial scenario without countervailing measures, etc. Because the model is static in the sense that economic effects are calculated "before-and-after," it was necessary to choose a uniform way to make assumptions about targets for all countries. First, to avoid complications, no assumptions were made about the future economic growth of countries, in particular none about any change in investment and other factors of production. Second, official country documentation or analytical reports provided the information about how countries arrive at their emissions projections, about which countries apply no measures to reduce emissions, and about which countries apply their stated policies along with the extent to which they implement them.[8] All targets were calculated as the percentage deviation of those projections from their 2030 NDC targets. The initial model was calibrated based on data from 2014, and in the GTAP model it is assumed that the initial carbon tax is zero. In fact, some countries implemented carbon regulations before 2014 [Organization for Economic.., 2016]. Nevertheless, it is assumed here that the reduction of emissions is relative to the initial state in the model.

Some countries have more ambitious targets than others. The Climate Action Tracker[9] determines whether the current target is sufficient to hold the global temperature increase to the 1.5 °C that averts an excessively negative impact on the environment. Many countries have set goals that are not sufficient to hold the temperature rise to 1.5 °C. However, for the purposes of this article, the goals that the countries have formulated for themselves as obligations under the Paris Agreement will be the benchmark applied.

A summary of the targets is provided below (Table 3). For the sake of brevity, the calculations for the EAEU and BRICS countries will be provided upon request. The manner of calculating the results for Russia is presented in full below. To make the model calculations less computationally intensive while preserving sufficient accuracy,[10] the relative structure of the goals is retained, and 75% of the ultimate 2030 target is employed as an intermediate goal prior to that year.

The following paragraph illustrates how emission reduction targets for Russia were calculated.

Russia has set a 30% reduction in emissions compared to 1990 as its target, based in part on the absorptive capacity of its forests. However, in this study the target for Russia is taken to be the average of the percent reductions projected in the "intensive" and "baseline" scenarios relative to the reduction forecast by the scenario "without support measures" as presented in the National Strategy of the Russian Federation.[11] For Russia the scenario without support measures assumes that emissions in 2030 will be 76% of the 1990 level (2,356 MT CO_2 eq). The baseline scenario assumes that emissions by 2030 will fall to 67% of the

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[8] This can be seen, for instance, in the Climate Action Tracker report projections which take into account stated policies and actions. https://climateactiontracker.org/methodology/cat-rating-methodology/. Another such tool is the European Environment Agency's projections for the scenario entitled "With Existing Measures." https://www.eea.europa.eu/en/datahub/datahubitem-view/4b8d94a4-aed7-4e67-a54c-0623a50f48e8.

[9] https://climateactiontracker.org/.

[10] For Armenia and Kyrgyzstan calculations for the whole target could not be carried out because the solution did not converge using the GEMPACK software (Dragg method and Euler method of optimization). It will become clear in subsequent sections of the article 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] Long-Term Development Strategy of the Russian Federation With Low Greenhouse Gas Emissions Through 2050. Government of the Russian Federation, 2021. https://economy.gov.ru/material/file/babacbb75d32d90e28d3298582d13a75/proekt_strategii.pdf.

Table 3

Emission Reduction Targets for Each Region (%)

Region	SourceC	Emission Reduction by 2030 Under the NDC (Compared to the Baseline Scenario) (X)	Estimated Scenario (X × 0.75)
Brazil (BRA)	https://climateactiontransparency.org/wp-content/uploads/2022/04/Deliverable-3_Brazil-Final-Report.pdf	16	12
China (CHN)	https://www.iea.org/data-and-statistics/charts/co2-emissions-reductions-in-china-2015-2060-by-scenario	18	14
India (IND)	https://www.cseindia.org/india-s-enhanced-climate-targets-and-commitments-what-do-they-mean--11043	22	17
Russia (RUS)	https://economy.gov.ru/material/file/babacbb75d32d90e28d3298582d13a75/proekt_strategii.pdf.	14	11
Southern Africa (SAF)	https://newclimate.org/sites/default/files/2019/09/19-9117_Factsheet_SouthAfrica_Country.pdf	22	17
Armenia (ARM)	https://ace.aua.am/files/2019/05/2015-Armenia's-Third-National-Communication-on-Climate-Change_eng.pdf	21	16
Belarus (BLR)	https://faolex.fao.org/docs/pdf/blr216649E.pdf	15	11
Kazakhstan (KAZ)	https://climateactiontracker.org/countries/kazakhstan/	29	22
Kyrgyzstan (KGZ)	https://unfccc.int/sites/default/files/NDC/2022-06/ОНУВ%20ENG%20от%2008102021.pdf	16	11
Uzbekistan, Turkmenistan (XSU)	https://unfccc.int/sites/default/files/resource/FBURUZeng.pdf; https://unfccc.int/sites/default/files/NDC/2023-01/NDC_Turkmenistan_12-05-2022_approv.%20by%20Decree_Eng.pdf	11	8
Other FSU countries (OFSU)	https://www.undp.org/sites/g/files/zskgke326/files/migration/tj/undp_tjk_Report_GHG_Projections_Tajikistan_2030.pdf	8	6
Latin and Central America (LCAM)	https://climateactiontracker.org/countries/mexico/; https://www.climate-laws.org/geographies/venezuela/climate_targets/Economy-wide; [Lallana et al., 2021]	25	19
East Asia (EAS)	https://climateactiontracker.org/countries/japan/; https://unfccc.int/sites/default/files/NDC/2022-06/211223_The%20Republic%20of%20Korea%27s%20Enhanced%20Update%20of%20its%20First%20Nationally%20Determined%20Contribution_211227_editorial%20change.pd	32	24

The end of the table 3

Region	SourceC	Emission Reduction by 2030 Under the NDC (Compared to the Baseline Scenario) (X)	Estimated Scenario (X × 0.75)
Southeast Asia (SEAS)	https://2050.nies.go.jp/report/file/lcs_asia/Malaysia.pdf; https://www.wri.org/news/statement-indonesia-submits-new-2030-climate-targets-and-first-long-term-climate-strategy; https://unfccc.int/sites/default/files/resource/Thailand_LTS1.pdf	24	18
South Asia (SAS)	https://unfccc.int/sites/default/files/NDC/2022-06/Pakistan%20Updated%20NDC%202021.pdf; https://unfccc.int/sites/default/files/NDC/2022-06/NDC_submission_20210826revised.pdf	12	9
West Asia and MENA (WASM)	https://unfccc.int/sites/default/files/NDC/2022-07/Egypt%20Updated%20NDC.pdf.pdf; https://www.climate-transparency.org/wp-content/uploads/2021/10/CT2021Turkey.pdf; https://climateactiontracker.org/countries/saudi-arabia/policies-action/ https://climateactiontracker.org/countries/iran/	16	12
EU, UK, EFTA, Eastern Europe (EU+)	https://www.eea.europa.eu/data-and-maps/data/greenhouse-gas-emission-projections-for-9	20	15
North America (NAM)	https://crsreports.congress.gov/product/pdf/R/R44451	28	21
Australia and New Zealand (PAC)	https://www.dcceew.gov.au/sites/default/files/documents/australias-emissions-projections-2022.pdf	22	17

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

1990 level (2,077 vs 3,100 MT CO_2 eq). The intensive scenario projects a reduction to 64% of 1990 levels (1,984 MT CO_2 eq). The difference between emissions under the baseline and intensive scenarios compared to the scenario without support measures ranges from 12% less to 16% less; hence, the average target for Russia would be 14% less.

5. Descriptive Statistics for Energy Balance and CO_2 Emissions by Country

According to statistical data for 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 4).

Table 4

Annual Carbon Emissions in 2021

Country	CO_2 (mln t)	Structure of Emissions Among Selected Countries (%)
Brazil (BRA)	482	3
China (CHN)	11,107	65
India (IND)	2,668	16
Russia (RUS)	1,724	10
South Africa (SAF)	451	3
Armenia (ARM)	7	0.04
Belarus (BLR)	61	0.4
Kazakhstan (KAZ)	287	2
Kyrgyzstan (KGZ)	9	0.1
Uzbekistan, Turkmenistan (UZB+TKM)	199	1

Source: 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.

The distribution of electricity production by source based on the country statistics for 2020 is in Table 5. While more than 80% of electricity is generated by combustion power plants in Belarus, Kazakhstan, Uzbekistan, Turkmenistan, and South Africa, coal accounts for more than 50% of emissions in Kazakhstan and South Africa according to GTAP data for 2014 (Table 6). Coal consumption is responsible for high emissions also in China (76%) and India (65%).

Table 5

Electricity Production by Source in 2020 (%)

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

Source: UN data http://data.un.org/Data.aspx?q=installed+capacity&d=EDATA&f=cmID%3aEC.

Table 6

Distribution of Energy Consumption Emissions by Country in 2014 (%)

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

Source: GTAP 10 data https://www.gtap.agecon.purdue.edu/databases/v10/index.aspx.

The volume of imported energy products is high in Armenia, Belarus, and Kyrgyzstan. South Africa consumes mainly coal but imports only 1% of it.[12] China consumes a substantial amount of coal,[13] and 15% of it is imported. India consumes both coal and petroleum products with imports comprising about 34% of coal and 11% of petroleum products (Table 7). Russia, Kazakhstan, and the combined Uzbekistan and Turkmenistan region all export substantial amounts of energy and account for a major proportion of that commerce. Brazil exports 18% of its oil production (Table 8) and ranked eleventh among the world's oil exporters in 2020. The structure of energy consumption and production among these economies is quite heterogeneous.

Table 7

Proportion of Imports in Consumption (%)

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

Source: GTAP 10 data https://www.gtap.agecon.purdue.edu/databases/v10/index.aspx.

Table 8

Proportion of Production Exported (%)

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

Source: GTAP 10 data https://www.gtap.agecon.purdue.edu/databases/v10/index.aspx.

6. Assessment of the Economic Effects of Carbon Regulation on the BRICS and EAEU Countries

In what follows, the effects of the carbon tax in each region are estimated separately (labelled 1 in Table 9) and compared with a scenario in which the ETS is introduced only in the EAEU countries (labelled 2) and in which there is an ETS between the BRICS and EAEU countries (labelled 3).

Russia, Belarus, Kyrgyzstan and Armenia would have less decrease in real GDP under an ETS implemented among the EAEU countries than under a separate carbon tax. However, an ETS throughout the EAEU would produce a greater GDP decrease for both Kazakhstan and Uzbekistan plus Turkmenistan. This implies that the initial costs of re-

[12] The Carbon Brief Profile: South Africa. Carbon Brief: Clear on Climate, 2018. https://www.carbonbrief.org/the-carbon-brief-profile-south-africa/.

[13] Energy Information Administration, 2022. https://www.eia.gov/international/analysis/country/CHN.

ducing emissions in the second group of countries are less than the new equilibrium ETS price.

A comparison of a carbon tax (1) to an ETS between the EAEU and BRICS (3) shows that the latter policy produces relatively favorable results for Russia, Brazil and India, but China's real GDP would fall by –0.14% to –0.19%, and South Africa's GDP would decline from –0.22 to –0.23% respectively (Table 9). This is because China and South Africa under an ETS would reduce their emissions even more than the target and derive revenue from selling their unused emission allowances to other countries. Lower initial abatement costs in the first scenario are partly due to the significant contribution of coal to the emissions in those countries. A similar decrease in GDP from –0.22 to –0.33% would occur in Uzbekistan plus Turkmenistan. At the same time, decreases in real GDP for Belarus, Kyrgyzstan, Kazakhstan, and Armenia would be less than under the carbon tax scenario. Sensitivity analysis shows that, if emission targets vary by 20% from the initial values, the standard deviation for projections of real GDP changes will vary from 0.0% (Brazil) to 0.03% (Uzbekistan plus Turkmenistan).

Table 9

Change in Real GDP Under Various Scenarios

Region	(1) Separate Carbon Tax		(2) EAEU ETS		(3) BRICS + EAEU ETS	
	change (%)	change (USD mln)	change (%)	change (USD mln)	change (%)	change (USD mln)
BRA	–0.20	–4,746	–0.20	–4,761	–0.02	–596
CHN	–0.14	–14,957	–0.14	–15,006	**–0.19**	**–20,124**
IND	–0.09	–1,801	–0.09	–1,822	–0.01	–247
SAF	–0.22	–820	–0.22	–821	**–0.23**	**–873**
RUS	–0.59	–11,969	–0.50	–10,249	–0.40	–8,088
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**	**–1,142**	–0.31	–696
KGZ	–0.66	–49	–0.29	–22	–0.14	–11
UZB + TKM	–0.22	–230	**–0.64**	**–683**	**–0.33**	**–351**

Note. Values in boldface are for the countries with greater decreases in GDP than under the first scenario.

Source: author's calculations.

The nominal tax for an emission trading system between the EAEU countries was set at 28 USD in 2014 prices per ton of CO_2. Under an ETS between the EAEU and BRICS countries, the nominal tax is 16 USD per ton of CO_2. Table 10 shows the effect of the carbon tax assuming separate taxation for each country and of the two ETSs along with the net revenue from trading emission allowances under each ETS.

The countries with greater decreases in real GDP would experience an increase in the carbon price. This increase ranges from 4% (China) to 41% (Uzbekistan plus Turkmenistan), but the carbon tax reduction ranges from –22% (Kazakhstan) to –89% (Armenia). Therefore, the principle 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 see an increase in the carbon price after joining an ETS would reduce their emissions even more, sell their unused carbon allowances, and derive a positive net income. This analysis identifies which countries could reduce their emissions at a relatively low cost.

Table 10

Change in Real Carbon Tax and Net Income from Emissions Trading

Region	Nominal Carbon price under Separate Carbon Tax (1)	Nominal Carbon price under EAEU ETS (2)	Net trading revenue from EAEU ETS (USD mln)	Nominal Carbon price under BRICS + EAEU ETS (3)	Net trading revenue from EAEU + BRICS ETS (USD mln)
BRA	72	72	0	16	–663
CHN	13	13	0	**16**	**3,302**
IND	22	22	0	16	–1,268
SAF	15	15	0	**16**	**38**
RUS	34	28	–689	16	–1,275
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**

Note. Values in boldface indicate countries that become sellers of carbon allowances under either ETS.

Source: author's calculations.

Changes in real output by sector are shown in the Table 11. For Russia there is a decrease in production of coal, oil, and electricity. The largest increase in real output is in the chemical industry and in ferrous and nonferrous metals. The direction of the trend holds even if Russia unilaterally raises its emissions reduction target from 11 to 16%.

Potential joint comparative advantages would accrue to the chemical industry in Belarus, Russia, Kazakhstan, Brazil, and India. Production of nonferrous metals would rise in Russia, Kazakhstan, South Africa, Uzbekistan plus Turkmenistan, and Armenia. Increased production of ferrous metals would come about mostly in Russia, China, Brazil, South Africa, and Armenia. All these industries are energy intensive, and the increase in their production indicates, first, that some countries would decrease their emissions by limiting activity in the energy sectors. Second, these industries have comparatively lower carbon intensities in some

Table 11

Changes in Sectoral Production Under a BRICS+EAEU ETS, Indexed to 2014 (USD mln)

Region	Industries Mostly Increase			Industries Mostly Decrease		
Brazil	**Chemicals**	**Ferrous metals**	Other energy-intensive products	Oil	Other industries and services	Composite of capital good
	1,964 (+1.4%)	1,296 (+1.9%)	534 (+0.4%)	–3,363 (–3.9%)	–2,811 (–0.1%)	–1,509 (–0.3%)
China	**Ferrous metals**	Agriculture	Mineral products	Coal	Electricity	Other industries and services
	473 (+0.04%)	413 (+0.04%)	365 (+0.04%)	–41,449 (–20.4%)	–37,638 (–7.6%)	–31,255 (–0.3%)
India	Oil products	**Chemicals**	Textile and apparel	Electricity	Coal	Machinery and transport equipment
	2,027 (+0.8%)	1,603 (+1.6%)	426 (+0.3%)	–10,165 (–4.7%)	–8,480 (–23.8%)	–3,148 (–1.5%)
Russia	**Chemicals**	**Nonferrous metals**	**Ferrous metals**	Other industries and services	Electricity	Composite of capital good
	4,494 (+9.9%)	3,792 (+6.9%)	3,085 (+4%)	–6,992 (–0.4%)	–5,981 (–3.5%)	–5,621 (–1.3%)
South Africa	**Nonferrous metals**	**Ferrous metals**	Food industry	Electricity	Coal	Other industries and services
	423 (+1.6%)	386 (+1.7%)	72 (+0.1%)	–2,981 (–18.3%)	–2,851 (–15.5%)	–890 (–0.2%)
Armenia	Electricity	**Nonferrous metals**	**Ferrous metals**	Other industries and services	Composite of capital good	Food industry
	34 (+6.7%)	9 (+3%)	4 (+4.9%)	–21 (–0.2%)	–21 (–0.9%)	–8 (–0.2%)
Belarus	**Chemicals**	Oil products	Composite of capital good	Food industry	Machinery and transport equipment	Electrical equipment
	147 (+2.8%)	127 (+0.6%)	125 (+0.4%)	–164 (–1%)	–118 (–0.9%)	–109 (–1.1%)
Kazakh-stan	**Nonferrous metals**	Other energy intensive products	**Chemicals**	Gas	Oil	Electricity
	932 (+12%)	446 (+3.1%)	443 (+9.5%)	–1,717 (–45.2%)	–1,318 (–2.7%)	–1,225 (–9%)
Kyrgyz-stan	Electricity			Nonferrous metals	Mineral products	Food industry
	11 (+0.6%)			–20 (–2%)	–19 (–6.2%)	–17 (–2.4%)
Uzbeki-stan plus Turkme-nistan	**Nonferrous metals**			Other industries and services	Electricity	Composite of capital good
	264 (+4.6%)			–597 (–0.6%)	–532 (–8.1%)	–446 (–1%)

Note. Sectors in boldface are those that would increase production the most in several countries at the same time.

Source: author's calculations.

countries than in others. For instance, Rusal, a major producer of aluminum in Russia has its factories located near hydroelectric power plants, and this ensures that Rusal's output has low carbon intensity. Belarus has relatively low emission intensities from its chemical industry. The model shows that the geographical distribution of production in the medium term would adjust in order for countries to meet emission reduction targets. Interestingly, only in Russia and Kazakhstan among the countries examined would there be an increase in the output of machinery and transportation and electronic equipment, albeit to a smaller extent. For Russia the increase in machinery and transportation equipment would come to USD 1.416 billion, and the increase in electronic equipment would amount to USD 1.354 billion. For Kazakhstan the corresponding increases would be USD 165 million and USD 195 million, respectively.

A transition from energy production to energy intensive goods would also take place in Russia's real exports. Exports of energy would decrease while exports of such energy intensive goods as chemical products as well as ferrous metals and nonferrous metals would increase (Table 12). For Kazakhstan the model predicts an increase in real exports and in real output for the chemical industry and nonferrous metals. The main export losses occur in the oil and gas sector; an increase in imports of gas from the Uzbekistan plus Turkmenistan region offsets this rather large drop. It is noteworthy that the decrease in Kazakhstan's gas sector is greater than in its coal sector. The GTAP data suggest that this is partly because the intensity of gas and coal emissions for several industries in Kazakhstan are comparable, although this point requires further research. China would export more ferrous metals, mineral products, and food. For the sake of brevity, details are not provided for each country, but a summary of the changes in real industrial production appears in Table 11, and information on exports in millions of US dollars indexed to 2014 is presented in Table 12.

Table 13 shows changes in prices for energy products and electricity. Domestic energy prices for a country would increase less under an ETS unless the country's costs to reduce emissions (carbon tax) were relatively low as in China, Uzbekistan plus Turkmenistan, and South Africa. The price of gas in almost all countries increases less than for coal, although the opposite is the case for Kazakhstan where the intensity of gas emissions in many industries is greater than for coal. The price for electricity under the carbon tax scenario ranges from 1.5% (Kyrgyzstan) to 40.4% (Armenia); under an ETS it varies from 0.6% (Kyrgyzstan) to 21.3% (South Africa).

China, South Africa, Uzbekistan, and Turkmenistan would have slightly lower real returns on capital and labor under an ETS than under a separate carbon tax. However, the differences between the two scenarios mostly run from 0.0 to 0.2%. South Africa is an exception

Table 12

Change in Real Sector Exports of Countries Under a BRICS+EAEU ETS, Indexed to 2014 (USD mln)

Region	Industries Mostly Increase			Industries Mostly Decrease		
Brazil	**Ferrous metals**	**Chemicals**	Other energy intensive products	Oil	Other industries and services	Food industry
	1,060 (+10.8%)	729 (+6.6%)	244 (+0.5%)	–2,606 (–17%)	–350 (–0.9%)	–320 (–0.7%)
China	**Ferrous metals**	Mineral products	Food industry	Electrical equipment	Machinery and transport equipment	Oil products
	4,751 (+6.7%)	1,870 (+4.2%)	354 (+0.8%)	–9,377 (–1%)	–4,565 (–1.5%)	–2,774 (–7.4%)
India	**Chemicals**	Other industries and services	Textile and apparel	Machinery and transport equipment	Ferrous metals	Nonferrous metals
	1,002 (+4%)	710 (+0.4%)	230 (+0.6%)	–1,402 (–4%)	–909 (–7.6%)	–808 (–6.8%)
Russia	**Chemicals**	Other industries and services	**Non-ferrous metals**	Oil	Gas	Coal
	3,951 (+14.4%)	3,308 (+5.7%)	2,666 (+10.8%)	–7,838 (–4.7%)	–4,851 (–6.1%)	–2,696 (–15.2%)
South Africa	**Non-ferrous metals**	**Ferrous metals**	Other industries and services	Other energy intensive products	Coal	Electricity
	418 (+1.7%)	351 (+4.6%)	171 (+1%)	–693 (–2.8%)	–554 (–8.1%)	–410 (–49.7%)
Armenia	Electricity	**Nonferrous metals**	**Ferrous metals**	Other industries and services	Food industry	Other energy intensive products
	38 (+48%)	8 (+3.2%)	4 (+7.4%)	–21 (–1.9%)	–11 (–2.8%)	–6 (–0.8%)
Belarus	Electricity	**Chemicals**	**Ferrous metals**	Food industry	Other industries and services	Machinery and transport equipment
	199 (+53.9%)	157 (+3.8%)	58 (+5.4%)	–179 (–4.7%)	–167 (–2.3%)	–96 (–3.1%)
Kazakh-stan	**Non-ferrous metals**	Other industries and services	**Chemicals**	Oil	Gas	Ferrous metals
	885 (+20.6%)	489 (+7.3%)	420 (+11.8%)	–1,595 (–3.5%)	–588 (–71%)	–321 (–8.6%)
Kyrgyz-stan	Electricity	**Ferrous metals**		Other industries and services	Agriculture	Nonferrous metals
	2 (+37%)	0.1 (+0.8%)		–49 (–7.4%)	–13 (–6.3%)	–11 (–1.7%)
Uzbeki-stan and Turkme-nistan	Gas	**Nonferrous metals**	Mineral products	Oil	Chemicals	Oil products
	600 (+8.5%)	222 (+10.2%)	1 (+1.8%)	–323 (–14.3%)	–207 (–29.5%)	–94 (–4.4%)

Note. Sectors in boldface are those that would increase exports the most in several countries at the same time.

Source: author's calculations.

Table 13

Real Change in Domestic Energy Prices (%)

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

Note. The real change in energy prices is the deviation of change in energy prices from average price inflation within each economy.

Source: author's calculations.

with returns on capital lower by 1.8% under a carbon taxation and by 2.4% under an ETS.

The changes in real return on capital parallel changes in real GDP. For buyers of allowances the decrease would be less under an ETS, while for sellers of carbon allowances (China, South Africa, Turkmenistan plus Uzbekistan) the rate of return is lower under an ETS. Kyrgyzstan stands out, however, for a return on capital that rises in both scenarios, as its electricity sector is the main driver of the demand for capital.

There are also some consequences for income inequality. In India the decrease in wages for unskilled labor is greater than for the skilled labor force, but joining an ETS slightly reduces this negative effect for both groups. A similar trend is evident in Belarus. In Russia and Kazakhstan, the reduction in wages for skilled labor is greater than for unskilled labor because skilled labor (technical workers) is involved in the energy sectors.

Table 14

Change in Real Return on Labor and Capital (%)

(1) Separate Carbon tax	BRA	CHN	IND	SAF	RUS	ARM	BLR	KAZ	KGZ	UZB + TKM
Unskilled labor	–0.4	–0.6	–0.6	–0.6	–1.4	–1.0	–1.2	–1.1	2.5	–0.7
Skilled labor	–0.5	–0.7	–0.2	–0.6	–1.8	–1.2	–0.6	–1.6	5.6	–0.4
Capital	–1.6	–1.6	–1.9	–1.8	–3.3	–5.7	–3.5	–3.0	0.6	–2.7
(2) BRICS + EAEU ETS	**BRA**	**CHN**	**IND**	**SAF**	**RUS**	**ARM**	**BLR**	**KAZ**	**KGZ**	**UZB + TKM**
Unskilled labor	–0.1	–0.6	–0.5	–0.8	–0.8	0.0	0.1	–0.8	0.9	–0.8
Skilled labor	–0.1	–0.7	–0.1	–0.8	–1.3	0.0	0.3	–1.3	1.9	–0.4
Capital	–0.4	–1.7	–1.5	–2.4	–2.1	–0.4	0.0	–2.3	0.8	–2.9

Source: author's calculations.

Terms of trade would decline for Russia, Kazakhstan, Uzbekistan plus Turkmenistan, and Brazil in both scenarios (Table 15). Among these countries, only Brazil's terms of trade would decline more under an ETS. This change in the terms of trade in Brazil is due mostly to changes in export prices. In China, India, South Africa, Belarus, Kyrgyzstan, and Armenia changes in the terms of trade are positive in all cases, and the change is slightly greater under carbon taxation.

Table 15

Changes in Terms of Trade (%)

Region	(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**

Note. Regions in boldface are those that would experience less favorable terms of trade.

Source: author's calculations.

In the countries studied where export of electricity increases, the FOB export price indices for electricity would increase by 4.0–4.4% while the average worldwide FOB price for electricity would increase by 16%. For energy intensive goods such as mineral products, nonferrous and ferrous metals, and the chemical industry, export prices would also increase by 0.2–2.8% among the countries studied that export such goods, while the average FOB price for those products would increase by 2.4–3.7%. As it becomes more expensive to produce such goods, specialization in those industries remains feasible only for countries that can reduce emissions by limiting their energy industries (gas, oil, coal) or that already have relatively low emission intensities compared to other countries. The FOB price decrease for oil, gas and coal runs from –0.6 to –2.0%. For the sake of brevity, no table with results for all industries is provided.

7. Current Renewable Energy Initiatives in the BRICS and EAEU Countries

The countries that would undergo a greater decline in real GDP under an emission trading scheme were identified in the previous section. However, the model does not include renewables. In this section, several foreign direct investment projects in the energy sector of BRICS and EAEU economies are described.

China is one of the largest investors in developing low-carbon technologies, solar and wind energy in particular.[14] China is carrying out FDI projects in Uzbekistan, South Africa, the southern regions of Russia, and other countries. According to analytical estimates, Uzbekistan is developing the use of solar energy because of its comparative advantage in climate conditions.[15, 16] Uzbekistan has concluded contracts with China to build solar farms with an energy capacity of 4 GW[17] (about 14% of the generating capacity planned by 2030[18]).

The IEA reports[19] that one of South Africa's goal is to increase energy generation from natural gas and renewable energy sources by at least 20 GW and decommission coal-fired power plants that produce 35 GW by 2030. In 2023 China offered to provide 66 GW of solar infrastructure for South Africa's grid.[20]

The experimental emission trading system in Sakhalin that Russia launched in 2022[21] is to be scaled up in the future. Kazakhstan and Russia have developed criteria for financing green projects.[22] Some researchers [Vinokurov et al., 2023] analyze the current state and the potential for an energy transition in the Eurasian region.

Practical considerations demand cooperation among countries for the introduction of renewable energy sources. For example, if countries have access to the same river and one country installs a hydroelectric power station upstream, this may restrict access to water and affect the agricultural sector of another country, as is the case for Kazakhstan, Kyrgyzstan, and Uzbekistan.[23] Another problem is the instability of renewable energy sources due to changes in weather conditions. That problem for energy security can be addressed by diversification of energy sources. As one example, Russia is involved in constructing nuclear power plants in Kyrgyzstan, Brazil, Turkey, and other countries.

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14 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/.

15 Uzbekistan Energy Information. https://www.enerdata.net/estore/energy-market/uzbekistan/.

16 Context of Renewable Energy in Uzbekistan. https://www.iea.org/reports/solar-energy-policy-in-uzbekistan-a-roadmap/context-of-renewable-energy-in-uzbekistan.

17 Chinese Companies Invest in Uzbekistan Solar Farms. https://www.investmentmonitor.ai/news/chinese-companies-invest-in-uzbekistan-solar-farms/?cf-view.

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19 South Africa Energy Outlook. https://www.iea.org/articles/south-africa-energy-outlook.

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22 Eurasion Economic Comission Criteria of Green Projects of the Eurasian Economic Union Member States. https://eec.eaeunion.org/upload/medialibrary/df7/Kriterii-dlya-opublikovaniya-_Modelnaya-taksonomiya_.pdf. (In Russ.)

23 Kyrgyzstan Considers Construction of Small Ground Nuclear Power Plant. https://www.kommersant.ru/doc/5173551. (In Russ.)

International investment projects can provide a solution for problems with energy supply stability, provided that comparative advantages in available energy sources, technologies, and climate are taken into consideration.[24] In general, joint carbon taxation should be coupled with investment projects in renewables and low-carbon technologies.

8. Conclusion and Policy Implications

This study compares the economic effects of a national carbon tax within countries to those of a joint carbon trading system in the EAEU and BRICS countries in the medium term. The emission targets are specified as 75% of their ultimate 2030 targets as pledged in NDC documents.

The model shows that in China, South Africa, and Uzbekistan plus Turkmenistan, real GDP declines more under an ETS policy than under a national tax, as these countries have relatively lower abatement costs. They would reduce emissions to a greater extent than is prescribed by their targets and generate positive net revenue from the sale of emission permits to other countries. This is partly because coal makes up a substantial proportion of the energy balance for China and South Africa, according to GTAP data. For the other countries an ETS would have a more favorable effect on real GDP than national taxation.

The analysis identifies which sectors could benefit from new comparative advantages in the context of declining global demand for energy from traditional resources. For example, Belarus, Kazakhstan, Russia, Brazil, and India could increase their exports of chemical products. Armenia, Kazakhstan, Russia, Uzbekistan plus Turkmenistan, and South Africa could export more nonferrous metals, while exports and output of ferrous metals would increase in Armenia, Brazil, China, and South Africa. It may seem counterintuitive that exports of chemicals and of nonferrous and ferrous metals would increase for such energy intensive industries. However, this is in part because the countries whose industries would benefit have lower emission intensities than the other countries. For instance, production of nonferrous metals in Russia has a rather low emission intensity compared to other regions. A second reason is that some of the countries specialize in exporting energy resources. The simulations show that CO_2 emissions of these countries would be reduced by limiting their energy sectors, and the factors of production withdrawn from energy production could then be redirected to the more energy intensive industries.

These industries could provide new comparative advantages to the EAEU and BRICS countries. However, maintaining those advantages

[24] Brazil's ENBPar and Rosatom Agree to Cooperate. https://www.world-nuclear-news.org/Articles/Brazils-ENBPar-and-Rosatom-agree-to-cooperate.

in the long term would require countries to cooperate in developing sector-specific technologies to make the production process more sustainable [Bashmakov et al., 2022].

One study [Volchkova et al., 2016] found that the chemical industry, machinery and equipment manufacturing, and the textile industry could generate joint potential comparative advantages for EAEU countries. The results of the present study indicate that the chemical industry in the EAEU and to a lesser extent the machinery and equipment sector in Kazakhstan and Russia could increase output; that is, these industries would remain sustainable under carbon regulation. These conclusions from the model coincide with the current proposals of the EAEU countries for joint economic development. Kazakhstan is placing a high priority on the production of electric-powered vehicles, railroad locomotives, agricultural and passenger vehicles, construction materials, and chemical products, as well as on the development of deposits of non ferrous and ferrous metals, as follows from the Eurasian Economic Forum 2023.[25]

The model employed for this study does not explicitly include the renewables sector or foreign direct investment. However, statistics confirm that China is investing in solar power industries in Uzbekistan, South Africa, and other countries. There is a BRICS Development Bank, which invests in energy projects.[26] If these projects are scaled up, the countries studied could reduce their emissions with lower production losses than the model predicts.

A logical next step for this kind of analysis would be to apply the GTAP-E-Power model, which incorporates data on renewable energy sectors. The sanctions imposed on Russian economy in 2022 are another aspect that was not considered in this study. Because these sanctions impact the export of energy and energy-intensive products, it is important for any subsequent research to consider changes in the geography of trade flows.

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