Prof. Irina Kalabikhina, Lomonosov Moscow State University — LMSU (Russia)
https://www.researchgate.net/profile/Irina_Kalabikhina

Assoc. Prof. Philipp Kartaev, Lomonosov Moscow State University — LMSU (Russia)
https://www.researchgate.net/profile/Philipp_Kartaev

Prof. Yannis Katsoulakos, Athens University of Economics and Business (Greece)
https://www.researchgate.net/profile/Yannis_Katsoulakos

Assoc. Prof. Alexander Kurdin, Lomonosov Moscow State University — LMSU (Russia)
https://www.researchgate.net/profile/Alexander_Kurdin

Prof. Andrey Panibratov, St. Petersburg State University (Russia)
https://www.researchgate.net/profile/Andrei_Panibratov

Prof. Andrey Shastitko, Lomonosov Moscow State University — LMSU; RANEPA (Russia)
https://www.researchgate.net/profile/Andrey_Shastitko

Prof. Jagdish Sheth, Emory University (USA)
https://www.researchgate.net/profile/Jagdish_Sheth

Prof. Galina Shirokova, St. Petersburg State University (Russia)
https://www.researchgate.net/profile/Galina_Shirokova

Assoc. Prof. Alina Steblyanskaya, Harbin Engineering University (China)
https://www.researchgate.net/profile/Alina_Steblyanskaya

Prof. Thomas Thurner, Higher School of Economics (Russia); Cape Peninsula University of Technology (Republic of South Africa)
https://www.researchgate.net/profile/Thomas_Thurner

Prof. Manuela Tvaronaviciene, Vilnius Gediminas Technical University (Lithuania)
https://www.researchgate.net/profile/Manuela_Tvaronaviciene

Prof. Shlomo Weber, New Economic School (Russia); Southern Methodist University (USA)
https://www.researchgate.net/profile/Shlomo_Weber

Prof. Wang Zhen, China University of Petroleum — Beijing (China)
https://www.scopus.com/authid/detail.uri?authorId=15823063000
Contents

Daniil Sitkevich, Agniya Konstantinova
   Urban development and interethnic intolerance: Evidence from Russia ............ 4

Ayushi Tiwari, Tridisha Bharadwaj,
   Assessing the impact of institutions on economic growth in the BRICS countries................................. 30

Samkelisiwe Bhebhe, Ian Ndlovu,
   The impact of world oil and food price shocks on the interdependence of Brazil and Russia: SVAR-DCC-GARCH model ...... 47

Agyemang Kwasi Sampene, Cai Li, Fredrick Oteng Agyeman, Robert Brenya,
   Analysis of the BRICS countries’ pathways towards a low-carbon environment .................................. 77

Olga Vinogradova,
   Effectiveness of forbearance measures for Russian commercial banks in the current crisis .......................... 103
Urban development and interethnic intolerance: Evidence from Russia

Daniil Sitkevich,*
Institute for Applied Economic Studies,
Russian Academy of National Economy and Public Administration (Russia)

Agniya Konstantinova,
Faculty of Economics, Lomonosov Moscow State University (Russia)


Abstract
This work is devoted to the study of the impact of urban development on interethnic intolerance. Although studies on the impact of urbanization and the economic well-being of cities on interethnic intolerance have been conducted in other countries, no similar scientific work has been conducted in Russia. The purpose of this paper is to determine factors related to urban development that influence the level of interethnic intolerance in a Russian city and to clarify the nature of this influence. The assumption of the presence of such an influence is based on the fact that the comfort of the urban environment can play the role of an indicator of economic well-being, while the exacerbation of social conflicts during periods of economic instability is scientifically substantiated. This influence is studied using an econometric study on a sample of 66 Russian cities with a population of over 100 thousand people, where 2 or more crimes motivated by interethnic intolerance were committed during the period 2007–2019. The information base for the study was obtained from the website of the SOVA Center for Information and Analysis, the statistical databases of Rosstat and EMISS, and the official website of the urban environment quality index. Based on the results obtained, it is concluded that interethnic intolerance is reduced due to a comfortable urban environment. Also, according to the study, in more populated Russian cities the level of interethnic intolerance is higher, whereas the incomes of city residents reduce it.

Keywords: urban development, interethnic intolerance, interethnic crime, tolerance, migration, Russian cities.

JEL: R11, R19.

* E-mail of the corresponding author: sitkevich@iep.ru
Introduction

Currently, one of the popular topics in economic research is the study of differences between social groups and their impact on the economic development. One of the main directions is the study of ethnic inequality, the manifestations of which may be associated with economic activity and the development of territories where certain groups live.

The issues of interethnic tensions in modern cities are becoming more and more acute. In the era of mass migration to big cities, there are a huge number of ethnic groups that constantly interact with each other. Thus, according to the Russian authorities, there are more than 10 million foreign citizens on the territory of the Russian Federation, the overwhelming majority of whom are citizens of Ukraine, Uzbekistan, Tajikistan, Azerbaijan, Kyrgyzstan, Armenia, and Moldova of working age. Although our society is developing very rapidly technologically, the same does not apply to the transformation of values — many prejudices, including xenophobic ones, are still strong.

The problem of the influence of the urban environment on interethnic intolerance is extremely poorly studied. Although studies on the impact of urbanization and the economic well-being of cities on interethnic intolerance have been conducted in other countries, no similar scientific work has been conducted in Russia. This work is the first research among Russian and foreign works that raises the question of the influence of the comfort of the urban environment on interethnic intolerance, and its practical novelty lies in conducting a study of the influence of various factors on xenophobia based on Russian data. The purpose of this paper is to determine factors related to urban development that affect the level of interethnic intolerance in a Russian city and to clarify the nature of this influence.

1. Literature review

Despite the lack of scientific clarity on the impact of urban development on ethnic intolerance, there are many studies on related topics that provide insight into the possible relationship between these indicators. One of the areas of research is the relationship between ethnic diversity and economic performance.

The connection between ethnic diversity and the economy has been extensively studied since the 2000s. One of the broadest studies is the research by Alesina and Ferrara (2005), which examined the impact of ethnic diversity in the United States on economic performance and the reasons for this impact. According to the results of testing the model (Alesina et al., 1999) which links the heterogeneity of preferences among different ethnic groups in the city with the amount and types of provided urban public goods spending on public goods (education, waste collection, road system) in the city is negatively connected with ethnic fragmentation, which makes it possible to analyze the significance of the impact of ethnic conflicts on local financing of public goods.

In another study by Ager and Brueckner (2018), given the influence of factors such as the rate of urbanization, incomes, and production growth, scientists concluded that
ethnic diversity and economic prosperity of the US counties in the period 1870–1920, which in the study was measured by the volume of production per capita, had a positive correlation. Another study by Alesina et al. (2016), which examined the relationship between intrapopulation diversity of birthplaces and economic prosperity, concluded that the diversity of immigrants relative to birthplace had a positive effect on economic prosperity, as indicated in the study by income per capita. Other scientists have come to the opposite results (Algan et al., 2016), having established the negative impact of ethnic diversity on the quality of housing in France.

At the same time, there is some evidence that ethnic diversity may have a negative impact. For example, research by Miguel and Gugerty (2005), based on data on ethnic diversity and public goods in rural areas of western Kenya, demonstrate that ethnic diversity has a negative impact on the state of public goods. The researchers explain this by the fact that the difficulty of imposing sanctions on ethnically diverse communities leads to unsuccessful collective actions, deteriorating opportunities for cooperation.

A study on the existence of discrimination in the rental market in France (Acolin et al., 2016), concerning applicants whose names indicate their connection with five different groups of immigrants, shows that geographical differences correlate with various indicators regarding local incomes of the population and the share of immigrants in the population. According to the study, discrimination against ethnic minorities is more pronounced in places with a large number of immigrants. In addition, discrimination against immigrants whose names are particularly susceptible to it is lower in areas, where the income of immigrants is higher relative to the income of indigenous people, as well as in places with high employment rates relative to the local population.

Ethnic diversity can have different impacts in different periods. According to Putnam (2007), although ethnic diversity has a negative impact over a short time, reducing trust in society and hindering the development of social capital, over a longer period, ethnic diversity has a positive effect on economic and cultural performance. This is because in the long run, new forms of social solidarity are being created in an ethnically diverse society, so the negative consequences of diversity are smoothed out.

The results at the micro level are also mixed. According to a study by Hjort (2014), based on data from a factory in Kenya, ethnic diversity negatively affected productivity in the private sector. In a study of more than 2,000 UK SMEs (Lee, 2015), Lee concludes that cultural diversity has a positive effect on the innovativeness of firms — companies with a large number of foreign-born owners or partners produce more innovation.

In another study based on the exogenous source of differences in population diversity between different ethnic groups, Arbatli and his colleagues (2020) conclude that it was the interpersonal population diversity, and not fractionalization or polarization between ethnic groups, that played a significant role in the occurrence, intensity, and likelihood of civil conflicts within various societies. In a study of the relationship between ethnic
fractionalization, polarization, and civil conflict, Montalvo and Reynal-Querol (2005) found that ethnic factionalism did not have a significant impact on the likelihood of civil wars in society, therefore, it probably could not exert an impact on economic performance. Nevertheless, based on cross-country data for 1960–1999, the researchers concluded that the index of ethnic polarization, on the contrary, was a significant factor affecting the frequency of civil conflicts.

Unemployment may be one of the reasons for the emerging interethnic intolerance — according to popular opinion, providing jobs to immigrants increases unemployment among the local population. Consequently, city dwellers can blame newcomers for the lack of jobs, which can increase interethnic intolerance. Based on data on 380 local US labor markets for 1995–2010, the results of the study show that, given the annual unemployment rate, the educational level of immigrants and the local population over the past decade and the annual level of anti-immigrant sentiment, attitudes towards immigrants are more negative in those places where the unemployment rate is higher (De Jong et al., 2017). It is worth noting that the identified impact is evident only for those places that have recently become the destination of immigrants. The skill level of migrants has a positive effect on attitudes towards them, but, according to scientists, the skill level of residents, which also has a positive effect on the perception of newcomers, is a more appropriate explanation.

However, studies of the impact of migration on unemployment indicate zero or little impact (Card, 2001). Based on data from 170 largest cities in the United States, the scientist concludes that the impact of immigrant flows on lower wages and employment rates of low-skilled workers in cities that traditionally have a relatively large share of low-skilled workers is about 1–3%. In a study of 120 US cities on the impact of immigration on the labor market for low-skilled workers (Altonji & Card, 1991), the researchers conclude that the increase in the flow of immigrants did not create a significant increase in competition for a job. At the same time, the scientists note that an increase in the flow of immigrants has a negative impact on the wages of low-skilled local workers, and the value of this indicator differs for different groups of the population and depends on the conditions of the local labor market. According to a study (Peri, 2012) based on the census years for 50 US states from 1960 to 2000 and 2006, immigration flows do not have a significant impact on employment.

It is important to remember that economic well-being itself can influence interethnic tensions. A study by Crepaz et al. (2009), based on data from 17 different countries, shows a positive effect of the level of decommodification (the strength of social benefits and the independence of citizens from market fluctuations) on the tolerance of indigenous people towards immigrants. Analyzing the causes, consequences, and types of xenophobia in South Africa (Lukong, 2011), Lukong finds that the reasons for the negative attitude towards migrants from other countries proceed from the fact that they create additional demand for limited resources and public goods (education, health care, housing, infrastructure). In addition, migrants are willing to work for smaller wages, which, against the background of high unemployment and layoffs, creates additional difficulties for the local population.
In its fact sheet on the impact of the economic crisis on discrimination and xenophobia (2009), UNESCO notes the following trend: for fear of increased competition for jobs with migrants, the local population forced some trade unions to require restricted entry for foreign workers. Research by the International Labor Organization (UN specialized agency) (2004) reveals that the percentage of respondents supporting discrimination in employment against minorities and migrants varies from 5% in Hungary to 65% in Russia. Moreover, data from the Russian Federation show that those who are dissatisfied with their incomes are more prone to discrimination.

In addition to the above, it is worth highlighting such a factor influencing interethnic intolerance as the level of education. In a study examining the factors of Japanese acceptance of foreigners (Nukaga, 2006), the author concludes that education has a significant impact in reducing xenophobia. The results show that age and the likelihood of an economic threat increase ethnic intolerance. In a study by Wodtke (2012), based on data from surveys conducted in the United States on the topic of racial discrimination, the researcher analyzes the impact of education on racial stereotypes and attitudes towards racial discrimination among whites, blacks, Asians, and Hispanics and concludes that a higher level of education reduces xenophobia. At the same time, respondents from Asia are an exception — many Asians, regardless of the level of education received, have a negative perception of blacks and Hispanics. The scientist notes that the results are consistent with the idea that education promotes the legitimization of the ideology of the dominant group among non-white minorities, and not evenly, but depending on their position in the racial hierarchy.

The results are validated at the cross-country level. A study by Hjerm (2001), based on data from 10 countries with different immigration policies and conditions for obtaining citizenship, concludes that with an increase in the level of education, the levels of xenophobia and nationalist sentiments, which were determined in the study with the help of information obtained from an international sociological survey conducted in 1995, are decreasing. This trend is observed for all countries in the sample, despite significant differences between their education systems.

Although cross-country studies often show negative or statistically insignificant relationships between ethnic diversity and economic well-being, analysis at the city level shows a positive impact of diversity on economic performance. For example, a study based on data on African cities (Montalvo & Reynal-Querol, 2021) reveals the positive impact of diversity on wages and productivity. Scientists find that the impact of ethnic diversity on economic growth is positive in the case of small geographic areas. Investigating how increased cultural diversity affects wages and rental prices in American cities, Ottaviano and Peri come to similar conclusions (2006).

The level of urban development, according to studies, can influence tolerance and, in particular, interethnic tensions and xenophobia. Huggins and Debies-Carl (2014) conclude that urban development has a positive effect on tolerance. In a research conducted on data from 29 countries, they study city and country factors influencing it. The following factors are used: size of the city, type of employment, income, education level, population density, religion, ethnic and linguistic fragmentation, age, sex, GDP.
Scientists conclude that the nature of the urban environment, determined in the study through the size of the city, has a uniquely positive effect on the residents’ tolerance, regardless of which group tolerance is tested for. In a study by Tuch (1987), examining the influence of the diversity and heterogeneity of urban life on racial prejudice, the author comes to the conclusion about the importance of the influence of the urban environment on racial intolerance. He defines the urban environment through the size of the settlement, referring places with a population exceeding 50,000 people to urban. Another study with a similar methodology for determining urbanized areas (Wilson, 1985), where tolerance is determined through the willingness of respondents to provide civil liberties to various social groups, concludes that the urban environment has a positive effect on tolerance. However, one of the fundamental studies on the influence the urban indicators on tolerance (Fischer, 1971) raises doubts about the influence of the city size and the urbanization level on the residents’ tolerance. At the same time, there are other results: tolerance increases with an increase in socioeconomic status and depends on geographic location and religion. It is also worth noting that the size of the city has different meanings as a factor of tolerance towards different social groups. Moreover, the size of the city is not the only dimension of urban development, as bigger cities may have worse living conditions, so the linkage between urban development and tolerance is still questionable.

Thus, the literature review shows that ethnic diversity has a mixed effect on the economy and the level of intolerance. Moreover, the source of intolerance may be related to economic factors — the situation in the labor market may be understood as a result of migration processes. However, we still do not know how much the comfort of the urban environment (which also affects a person’s perceived well-being) is related to the level of intolerance. It is this question that we are trying to answer in this article.

Based on this, we put forward the following hypothesis:

\[ H1: \text{The comfort of the urban environment of a Russian city negatively affects the level of ethnic intolerance in the city.} \]

In addition, it is worth looking at how much the size of the city itself is related to the level of tolerance or if this indicator is just a proxy for assessing the quality of the urban environment. Therefore, we put forward the following hypothesis based on past research:

\[ H2: \text{The size of a Russian city negatively affects the level of ethnic intolerance in the city, regardless of the quality of the urban environment.} \]

Another interesting question is to what extent the economic well-being of the city can be associated with the level of ethnic intolerance. Therefore, we put forward the following hypothesis:

\[ H3: \text{The average income of residents negatively affects the level of ethnic intolerance in a Russian city.} \]

These hypotheses are tested on data from Russia — a country whose cities differ significantly in the quality of the urban environment and in which detailed statistics of crimes related to interethnic intolerance are maintained.
2. Interethnic intolerance in Russia: Existing data and previous research

The processes of transformation of Russian society during and after the collapse of the Soviet Union led to an increase in interethnic tensions in all ex-Soviet republics, including Russia. Despite the “friendship of peoples” discourse promoted by the communist government, in the 1990s, sociologists recorded an increase in xenophobia and hostility to representatives of other nationalities (especially labor migrants) among former representatives of the “Soviet people” (Achkasov, 2008). Both migrants and representatives of ethnic minorities in regions with the predominance of Russians, as well as Russians themselves in regions where they are a minority, faced xenophobia and discrimination in the 1990s and 2000s (Drobizheva, 2005).

The high level of ethnic intolerance in Russian society is also expressed by the large number of crimes connected to interethnic and interfaith intolerance. Thus, according to the SOVA Center for Information and Analysis, which studies interethnic relations in Russia, 2,330 crimes of this type were committed from 2007 to 2019. Figure 1 shows a crime map for this period. Victims of crimes caused by interethnic intolerance included the following categories: people from Central Asia, black people, people from other Asian countries, Jews, people from the Caucasus, people of “non-Slavic appearance,” people from the Middle East and North Africa. Beatings, injuries, death threats/reprisals are marked in red and murders are marked in black.

Source: SOVA Center for Information and Analysis.

Figure 1. Map of crimes motivated by interethnic intolerance

---

1 The crimes were classified as “related to interethnic intolerance” and “related to other factors” based on the information on the categories of victims provided by the SOVA Center for Information and Analysis.
As it can be seen on the map, most of the crimes occurred in places located in close proximity to the national borders and in Central Russia. A relatively large part of immigrants from other countries and the North Caucasus traditionally live in these places on a permanent or temporary basis.

The distribution of crimes by year is shown in Figure 2. It can be noted that over time there has been a significant decrease in the number of xenophobic crimes. This is due, firstly, to a decrease in the overall crime rate in Russia (as in other countries, there is a steady decrease in the number of violent crimes regardless of their motivation), and secondly, to a decrease in the level of xenophobia, which has been recorded by the Levada Center since 2014.²

![Figure 2](https://www.levada.ru/2019/09/18/monitoring-ksenofobskih-nastroenij-2/)

**Figure 2.** Dynamics of crimes motivated by interethnic intolerance by year

The most vulnerable group are people from Central Asia, the Caucasus, and other people of “non-Slavic” appearance. The smallest number of crimes due to interethnic intolerance were committed against Jews (which can be explained by the fact that a significant number of Jews historically live on the territory of Russia) and Arabs (which is rather explained by their small number since Russia is not a popular country for migration from the Arab world). If we study the dynamics based on regional indicators, we can see that a significant part of crimes occur in Moscow, St. Petersburg, and their surroundings. In this regard, they are presented separately in Figure 3.

---

Speaking about the quantitative analysis of xenophobia in Russia, it should be admitted that the number of studies conducted on that topic is quite small. The first large-scale experiment on interethnic intolerance in Russia was conducted relatively recently (Bessudnov & Shcherbak, 2019). The researches sent more than 9,000 employment applications from representatives of 10 ethnic groups of different genders and professions. The study involved 4 Russian cities — Moscow, St. Petersburg, Ufa, and Kazan. The choice was dictated by differences in ethnic structure: in Moscow and St. Petersburg, the percentage of the Russian population is significantly higher than in Kazan and Ufa. According to the results of the experiment, there was no significant statistical difference between Russian, Jewish, and Ukrainian applicants. At the same time, applicants from European countries received approximately 5% fewer responses, from Central Asia — 12% less, and applicants from the Transcaucasian countries — 15% less. However, gender can play a significant role, especially for applicants from West and Central Asia.

Earlier, in a study on xenophobia in Russia (Alekseev, 2013), three main conclusions were made. First, ethnic minorities are less hostile towards migrants than the ethnic majority. Second, whether an ethnic group has a historical relationship to the locality since the Soviet period plays a more significant role than religion or ethnicity. That is, “historical” ethnic groups have more explicit anti-migrant views. Third, tolerance and intolerance are asymmetric. So, intolerance towards migrants tends to be more pronounced.

Source: calculated by the authors based on the data of the SOVA Center for Information and Analysis.

Figure 3. The dynamics of crimes motivated by interethnic intolerance by year in Moscow, the Moscow Region, St. Petersburg and the Leningrad Region
Speaking about the factors that affect the level of xenophobia in Russia, the following can be noted:

- The spread of social networks: the higher the proportion of citizens using social networks in regions with historically observed resentment towards representatives of other nationalities, the higher the number of inter-ethnic crimes committed (Bursztyn et al., 2019).
- Natives of Moscow, as well as the unemployed, demonstrate more xenophobic views than average Russians, while there are no differences between citizens with different income levels (Hannah et al., 2018).

At the same time, these works note that there are significant differences in the level of interethnic intolerance between the regions, which were observed even before the advent of social networks and are not related to unemployment. In the empirical part of the work, we check how these differences are related to the quality of life in the city.

### 3. Model and data description

The following models are used to test the hypotheses:

\[
Interethnic\_Crimes_i = \beta_0 + \beta_1 \ast urban\_environment_i + \\
+ \beta_2 \ast size\_of\_town_i + \beta_3 \ast aggregate\_income_i + \beta_4 \ast unemployment_i + \\
+ \beta_5 \ast density_i + \beta_6 \ast share\_of\_minorities_i + \beta_7 \ast education_i + \\
+ \beta_8 \ast age\_structure_i + \beta_9 \ast national\_rep\_i + \beta_{10} \ast close\_to\_Moscow_i + \\
+ \beta_{11} \ast criminality_i + \beta_{12} \ast migration_i + \beta_{13} \ast media_i + \beta_{14} \ast distance_i + \\
+ \beta_{15} \ast poverty\_line_i. \quad (1)
\]

\[
Interethnic\_Crimes_i = \beta_0 + \beta_1 \ast housing_i + \beta_2 \ast streets_i + \beta_3 \ast green\_spaces_i + \\
+ \beta_4 \ast public\_and\_business_i + \beta_5 \ast social\_and\_leisure_i + \beta_6 \ast citywide_i + \\
+ \beta_7 \ast size\_of\_town_i + \beta_8 \ast aggregate\_income_i + \beta_9 \ast unemployment_i + \\
+ \beta_{10} \ast density_i + \beta_{11} \ast share\_of\_minorities_i + \beta_{12} \ast education_i + \\
+ \beta_{13} \ast age\_structure_i + \beta_{14} \ast national\_rep\_i + \beta_{15} \ast close\_to\_Moscow_i + \\
+ \beta_{16} \ast criminality_i + \beta_{17} \ast migration_i + \beta_{18} \ast media_i + \beta_{19} \ast distance_i + \\
+ \beta_{20} \ast poverty\_line_i. \quad (1*)
\]

\[
Interethnic\_Crimes_i = \beta_0 + \beta_1 \ast size\_of\_town_i + \beta_2 \ast aggregate\_income_i + \\
+ \beta_3 \ast unemployment_i + \beta_4 \ast density_i + \beta_5 \ast share\_of\_minorities_i + \\
+ \beta_6 \ast education_i + \beta_7 \ast age\_structure_i + \beta_8 \ast national\_rep\_i + \\
+ \beta_{9} \ast close\_to\_Moscow_i + \beta_{10} \ast criminality_i + \beta_{11} \ast migration_i + \\
+ \beta_{12} \ast media_i + \beta_{13} \ast distance_i + \beta_{14} \ast poverty\_line_i. \quad (2)
\]

The dependent variable \textit{Interethnic Crimes} is the number of interethnic crimes in the city, which is counted by the SOVA Center for Information and Analysis. The values
of this variable are calculated as a relative indicator equal to the absolute number of crimes in the considered city for each year divided by the population of this city and multiplied by the average population of the cities in the sample. As Egorov et al. (2020) show, this metric is a good proxy for the level of interethnic intolerance in the city.

In our models we use several test variables:

- **urban_environment** — an indicator of the comfort of the urban environment. The urban environment quality index developed by the Ministry of Construction, Housing and Utilities of the Russian Federation is used as data for this variable. The variable is used to test Hypothesis 1

- **size_of_town** — the size of the city; takes values from 1 to 7. 1 corresponds to cities with a population of up to 250 thousand people; 2 — cities with a population ranging from 250 to 500 thousand people; 3 — cities with a population of 500 to 750 thousand people; 4 — cities with a population of 750 to 1 million people; 5 — cities with a population of 1 to 3 million people; 6 - cities with a population of 3 to 6 million people; and 7 — cities with a population of over 6 million people. The variable is used to test Hypothesis 2

- **aggregate_income** — the logarithm of the average monthly income of a city resident in rubles according to Rosstat. The variable is used to test Hypothesis 3

- **unemployment** — the unemployment rate in the region (%) according to Rosstat

- **density** — the population density in the city, thousand people per sq. km of land area according to Rosstat. This variable is necessary as an important characteristic of the urban environment, traditionally used in research on the influence of the urban environment on tolerance. Population density can influence the frequency of interactions between people and hence the likelihood of interethnic crime

- **share_of_minorities** — the share of the non-Russian population (%) according to All-Russian Population Census of 2010

- **education** — the share of the population with higher education (%) according to All-Russian Population Census of 2010

- **age_structure** — the proportion of the adult non-elderly population (%) according to Rosstat. The use of this variable is due to the fact that the older generation is less likely to engage in physical conflicts, therefore, a significant proportion of the elderly population in the city can influence the number of crimes motivated by interethnic intolerance

- **national_republic** — a binary variable that takes the value 1 if the city belongs to one of the national republics within the Russian Federation, and 0 otherwise

- **close_to_Moscow** — a variable for the cities of the Moscow Region. Its value depends on the distance to the Moscow Ring Road. This variable equals 4 if the distance does not exceed 10 km; 3 — if the city is located at a distance of 10 to 20 km; 2 — at a distance of 20 to 30 km; and 1 — if the distance to the Moscow Ring Road exceeds 40 km

- **criminality** — the number of murders in the city per year according to Rosstat. The use of this variable is due to the fact that the number of interethnic crime...
crimes maybe correlated with the total number of crimes. The values of this variable are calculated as a relative indicator equal to the absolute number of homicides in the city under consideration for each year divided by the population of that city and multiplied by the average population of the cities in the sample

- migration — an indicator of migration in the region according to Rosstat. The values of this variable are calculated as a relative indicator equal to the absolute number of migrants from other countries arriving in the region divided by the population of this region and multiplied by the average population of the cities in the sample

- media — a variable reflecting the index of the development of the media sphere. This variable was added to our regressions as SOVA data is based on news analytics, and the number of described crimes in some cities may be lower because of the less free press. We use data from the Mediastandart Foundation, which calculate the media sphere development rating for each region. 4 corresponds to the rating “A” — the most developed region; 3 — “B” — a developed region; 2 — “C” — an underdeveloped region; 1 — “D” — the least developed region

- distance — a variable for cities that are not regional centers and do not belong to the Moscow Region, taking values equal to the distance from the city to the corresponding regional center (km)

- poverty_line — the proportion of the population with monetary incomes below the subsistence level established in the constituent entity of the Russian Federation (%) according to Rosstat

- housing — a variable that takes the values of the index component that characterizes housing and adjacent spaces: apartment buildings, individual residential sectors

- streets — a variable that takes the values of the index component that characterizes the road network: streets, driveways, embankments

- green_spaces — a variable that takes the values of the index component characterizing green spaces: parks, squares, green embankments, gardens, etc.

- public_and_business — a variable that takes the values of the component of the index characterizing the public and business infrastructure and adjacent spaces: objects of services, catering, administrative institutions, etc.

- social_and_leisure — a variable that takes the values of the component of the index characterizing the social and leisure infrastructure and adjacent areas: educational institutions, medical institutions, sports, leisure and recreation, cultural institutions, etc.

- citywide — a variable that takes the values of the index component that characterizes the citywide space: the entire territory within the city boundaries.

In the course of working with the data, regions where the number of crimes for the 13 years under consideration was less than 10 were removed from the sample (a total of 32 regions were excluded). Data for the remaining regions, except those considered in Figure 3, are presented in Table A1 in Appendix A.
Thus, the study is based on a sample of 66 Russian cities with a population of over 100 thousand people where 2 or more crimes motivated by interethnic intolerance were committed during the period 2007–2019. A total of 858 observations are considered in the study. It is worth noting that, although this metric for measuring xenophobia is generally recognized, it has a certain distortion — the database includes only those cases that get into the media, which, in turn, are guided by topics that are relevant and popular among readers, so this metric can speak not only about the level of interethnic intolerance but also about the level of interest in xenophobic issues, which, in turn, is a sign of interethnic tension.

Data for the *urban_environment* variable, an indicator of the comfort of the urban environment, were obtained from the official website of the urban environment quality index developed by the Ministry of Construction, Housing and Utilities of the Russian Federation. Data for the variables *housing, streets, green_spaces, public_and_business, social_and_leisure, citywide* were obtained from the same source.

The urban environment quality index is calculated by evaluating 6 types of urban spaces in accordance with 6 criteria for the quality of the urban environment, that is, based on an assessment matrix consisting of 36 indicators, each of which can take values from 0 to 10, where 10 is the best grade. Thus, the values of the urban environment quality index range from 0 to 360, and the urban environment is considered favorable if the index value is in the range from 181 to 360 points. At the same time, the values of those indicators that are calculated for the entire city are also added to individual types of spaces. Let us consider in more detail the types of spaces assessed: housing and adjacent spaces; public and business infrastructure and adjacent spaces; street and road network; green spaces; social and leisure infrastructure and adjacent spaces; city-wide space. Evaluation is carried out according to the following criteria: safety; environmental friendliness and health; modernity and relevance of the environment; comfort; identity and diversity; management efficiency. The index was first calculated in 2018, and from that moment it is calculated once a year. The study uses values for 2018 and 2019.

The values for the variables *size_of_town*, reflecting the population in each city for each year, *density*, which reflects the density of the city's population, *aggregate_income*, reflecting the income of the urban population, *unemployment*, reflecting the level of unemployment among the urban population, *poverty_line*, reflecting the proportion of the population whose incomes are below the subsistence level, and *migration* were obtained from the website of the Rosstat.

The values for the variables *share_of_minorities*, which reflects the share of the non-Russian population, *education*, which reflects the share of people with higher education, and *age_structure*, which reflects the share of the adult non-elderly population, were obtained from the data of the All-Russian Population Census 2010. These variables are constants, which is acceptable since they do not change significantly over several years. It should be noted that the main variation in the share of the non-Russian population is associated with the presence of titular nationalities, whose share changes in the same way as the share of the Russian population.
Data for the variable *criminality*, which denotes the number of homicides in the region, were obtained from the official website of the state statistics EMISS. The values for the *media* variable, which denotes the index of media development, were obtained from the website of the Mediastandard Foundation.

Figure 4 below shows the distribution of the Interethnic_Crimes dependent variable. The presence of explicit outliers in the distribution is obvious.

![Interethnic_Crimes](image)

*Source:* calculated by the authors based on data from the SOVA Center for Information and Analysis.

**Figure 4.** The Interethnic_Crimes variable

The following outliers in the distribution were excluded:

1. Blagoveshchensk, 2009 — a total of 9 victims, a group of young people threw stones at Chinese workers, and there was also a massive brawl - an attack on black cadets of a military school.
2. Voronezh, 2008 — a total of 22 victims, a neo-Nazi organization was operating.
3. Lipetsk, 2013 — a total of 18 victims, a series of similar attacks, according to some sources, from an ultra-right group.

A significant part of the emissions occurred in 2007–2009 when there was a surge in nationalist sentiments in Russia.

As these crimes were committed by a certain criminal organization of a certain murderer, they do not represent the overall population, we consider a series of attacks to be one crime. After excluding outliers in the distribution, the graph of the variable values looks as shown in Figure 5.
Figure 5. Variable Interethnic_Crimes after excluding outliers in the distribution

After eliminating the outliers in the distribution, 852 observations remained in the sample. Tables A2 and A3 in Appendix A provide information about the values of the variables.

5. Results and discussion

Models (1) and (1*) are tested on a sample of data for 2018–2019, because the urban environment quality index was not calculated until 2018. Model (2) testing is carried out on a sample of data for 2007–2019.

The choice of the Weighted LS method is due to the following: the study is carried out only on data for two consecutive years, the difference between which is insignificant. The F-test of the fixed effects model gives a $p$-value of 0.8 (in the case of Model 1*, the $p$-value is 0.9), therefore, one can opt for the WLS method. The results for Model 1 are presented in the first column of Table B1 in Appendix B.

According to the regression results, the variable *urban_environment* has a serious influence on the level of interethnic intolerance. Other significant variables are *the_size_of_a_town*, *national_republic* and *Moscow_region* variable, *education*, *share_of_minorities_media* and *level_of_poverty*. The results for Model (1*) are presented in the second column of Table B1 in Appendix B. According to the regression results, the interest variables *housing*, *green_spaces*, *public_and_business* are significant.

Model (2) is tested on data for 13 years. Let's first estimate it by using a fixed effects model. The results are presented in Table B2 in Appendix B. According to the regression results, the interest variables *size_of_town* and *aggregate_income*
are significant. The following control variables are also significant: density, unemployment, criminality.

When using this method, the \( p\)-value of the F-test is less than 0.01. However, since some variables are constants, they were excluded from the model, making it impossible to assess their impact on the dependent variable. In this regard, we use the usual OLS with the addition of binary variables for each year and get the results presented in Table B3 in Appendix B. The following variables are significant: close_to_Moscow, age_structure, education, density, aggregate_income, criminality.

According to the results obtained by testing Model (1), Hypothesis 1 is confirmed. This means that, probably, the comfort of the urban environment in a Russian city can play the role of an indicator of economic well-being, thereby reducing the level of interethnic intolerance in society. Although such an influence is likely, it is not yet possible to assert for sure — for a more accurate conclusion, a study of a much larger number of years is needed, which will become feasible in the coming years.

Testing of Model (1 *) allows us to consider the impact of each component of the index. According to the results obtained, quality housing and green spaces in a city may themselves be indicators of economic well-being. However, in the case of public and business infrastructure, the situation is different — it positively correlates with interethnic crimes. The public and business infrastructure includes objects of services and services, and public catering, that is, places where people from other countries who are ready to work for less pay are traditionally in demand. In addition, this can be explained by the fact that in those Russian cities where there is an active construction and modernization of such buildings, migrant workers are likely to be attracted.

After testing Model (2) with the FE model, the following results were obtained. Hypothesis 2 is confirmed, that is, the size (population) of a Russian city affects the level of interethnic intolerance in it. According to the study, the level of interethnic intolerance is worse in more populated Russian cities. This can be explained by the peculiarities of life in a big city: a huge flow of people of various beliefs and views, a greater opportunity (compared to a small city) not being caught committing a crime.

We can unequivocally speak about the confirmation of Hypothesis 3 — the incomes of city residents have a significant impact on the level of interethnic intolerance in it, reducing it. This confirms the relevance of the conclusions of foreign studies concerning Russian data.

It is also worth mentioning the significant influence of the following factors: unemployment, population density, and the number of homicides, with the latter two factors having a negative impact on the number of crimes motivated by interethnic intolerance. The latter can be explained by the fact that with a high crime rate, the region is less attractive for immigrants, who are a vulnerable group. Moreover, in cities with high homicide rates, additional murders are not significant news and are less likely to hit the news, and therefore less likely to get into the database. In the case of density, it can be assumed that this is due to economic development — the more developed and richer the city, the higher the population density there, thus, this is a consequence of the economic prosperity of the city, which can reduce the level of interethnic intolerance.
The unemployment rate is positively associated with the level of interethnic intolerance in a Russian city, which can be caused by both an increase in economic insecurity and an increase in competition for jobs.

Since some of the variables in our model are constant over time, we cannot estimate their significance using panel regression with fixed effects. Therefore, we use the usual OLS, taking into account the variables associated with time periods.

Thus, according to the regression with the OLS, we can say that the influence of the share of ethnic minorities is insignificant — in more ethnically heterogeneous Russian cities, there is no greater number of crimes motivated by interethnic intolerance. This can be explained by the historical context of the country: since a certain number of ethnic minorities historically live in Russia, they are not considered “immigrants,” and their residence in the territory is taken for granted by the ethnic majority.

In addition, this method provides some information about other missing variables. Thus, proximity to Moscow, age structure, and education have a significant impact, and proximity to Moscow and the proportion of the adult working population reduce the number of crimes motivated by xenophobia, while the proportion of people with higher education, on the contrary, positively correlates. The first factor can be explained by the fact that the closer a city near Moscow is to the Moscow Ring Road, the more expensive housing there is and the more economically prosperous people live there. The second factor can be explained by the fact that the share of the adult working-age population can be a signal of the well-being of the city since working-age adults are likely to choose more prosperous cities with greater opportunities for career growth. In the case of education, apparently, the influence of this factor cannot be interpreted at the moment and further research is needed. Perhaps in further studies it makes sense to consider not the proportion of people with higher education, but the average number of years of education in the adult population, the proportion of people without education, except for school, etc.

Thus, urban development, the comfort of the urban environment can reduce the level of interethnic intolerance in the city. In addition, factors such as the well-being of city residents, the level of employment in the city, and its ethnic structure may play a role. All this allows us to conclude that in more developed (comfortable, wealthy) Russian cities with a high level of employment, the level of interethnic intolerance may decrease.

**Conclusion**

This work is devoted to the study of the factors of urban development that affect interethnic intolerance in Russian cities. In the course of the work, the factors influencing the cases of manifestation of xenophobia were considered. Based on the analyzed scientific literature, it can be concluded that manifestations of xenophobia depend on economic stability and some urban characteristics.

The analysis included 66 Russian cities with a population of over 100 thousand people, where two or more crimes motivated by interethnic intolerance were committed during
Urban development and interethnic intolerance: Evidence from Russia

the period 2007–2019. Two samples were formed for the study: the first included 132 observations for the period 2018–2019, the second included 852 observations for the period from 2007 to 2019.

Based on the results of the empirical study, it was found that the following factors affect the level of interethnic intolerance in a city: the quality of the urban environment, the size of the city, the incomes of its residents, employment in the city, population density, and age structure. The higher each of the indicators, the lower the interethnic intolerance.

The results obtained in this work complement the field of research devoted to the study of factors influencing interethnic intolerance in cities. First of all, the results were obtained on the influence of the quality of the urban environment on interethnic tension in cities. Moreover, the results from the previously unexplored Russian market were supplemented.

A more detailed study of the influence of the quality of the urban environment on the manifestations of xenophobia can be considered as one of the highest priorities for further research. There is also a need for a deeper study of how factors such as ethnic diversity in a city and education of its inhabitants influence interethnic intolerance.

References


### Appendix A. Descriptive statistics

Table A1. The number of crimes motivated by interethnic intolerance by region

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of crimes</th>
<th>Region</th>
<th>Number of crimes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omsk Region</td>
<td>10</td>
<td>Tula Region</td>
<td>21</td>
</tr>
<tr>
<td>Republic of Bashkortostan</td>
<td>10</td>
<td>Volgograd Region</td>
<td>22</td>
</tr>
<tr>
<td>Republic of Karelia</td>
<td>10</td>
<td>Oryol Region</td>
<td>22</td>
</tr>
<tr>
<td>Ulyanovsk Region</td>
<td>10</td>
<td>Penza Region</td>
<td>25</td>
</tr>
<tr>
<td>Yaroslavskaya Oblast</td>
<td>10</td>
<td>Lipetsk Region</td>
<td>26</td>
</tr>
<tr>
<td>Tomsk Region</td>
<td>11</td>
<td>Kaluga Region</td>
<td>27</td>
</tr>
<tr>
<td>Republic of Adygea</td>
<td>11</td>
<td>Primorsky Krai</td>
<td>27</td>
</tr>
<tr>
<td>Kirov Region</td>
<td>12</td>
<td>Ryazan Oblast</td>
<td>27</td>
</tr>
<tr>
<td>Perm Territory</td>
<td>12</td>
<td>Vladimir Region</td>
<td>28</td>
</tr>
<tr>
<td>Khabarovsk Region</td>
<td>14</td>
<td>Novosibirsk Region</td>
<td>30</td>
</tr>
<tr>
<td>Altai Region</td>
<td>15</td>
<td>Samara Region</td>
<td>31</td>
</tr>
<tr>
<td>Republic of Tatarstan</td>
<td>15</td>
<td>Krasnodar Region</td>
<td>33</td>
</tr>
<tr>
<td>Amurskaya Oblast</td>
<td>16</td>
<td>Sverdlovsk Region</td>
<td>37</td>
</tr>
<tr>
<td>Tver Region</td>
<td>17</td>
<td>Stavropol Region</td>
<td>39</td>
</tr>
<tr>
<td>Chelyabinsk Region</td>
<td>18</td>
<td>Voronezh Region</td>
<td>44</td>
</tr>
<tr>
<td>Kaliningrad Region</td>
<td>20</td>
<td>Nizhny Novgorod Region</td>
<td>87</td>
</tr>
<tr>
<td>Rostov Region</td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: SOVA Center for Information and Analysis.

Table A2. Values of variables in Models (1) and (1*)

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interethnic_Crimes</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>urban_environment</td>
<td>187</td>
<td>27</td>
<td>104</td>
<td>283</td>
</tr>
<tr>
<td>size_of_town</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>national_republic</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>close_to_Moscow</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>age_structure</td>
<td>62</td>
<td>2</td>
<td>59</td>
<td>68</td>
</tr>
<tr>
<td>education</td>
<td>24</td>
<td>4</td>
<td>18</td>
<td>40</td>
</tr>
<tr>
<td>share_of_minorities</td>
<td>12</td>
<td>11</td>
<td>3</td>
<td>64</td>
</tr>
<tr>
<td>density</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>aggregate_income</td>
<td>11</td>
<td>0</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>unemployment</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>
### Table A2. Continued

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>migration</td>
<td>766</td>
<td>888</td>
<td>33</td>
<td>4139</td>
</tr>
<tr>
<td>criminality</td>
<td>45</td>
<td>24</td>
<td>13</td>
<td>139</td>
</tr>
<tr>
<td>media</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>distance</td>
<td>9</td>
<td>33</td>
<td>0</td>
<td>225</td>
</tr>
<tr>
<td>poverty_line</td>
<td>12</td>
<td>3</td>
<td>7</td>
<td>22</td>
</tr>
<tr>
<td>housing</td>
<td>37</td>
<td>7</td>
<td>16</td>
<td>55</td>
</tr>
<tr>
<td>streets</td>
<td>30</td>
<td>7</td>
<td>10</td>
<td>48</td>
</tr>
<tr>
<td>green_spaces</td>
<td>27</td>
<td>8</td>
<td>7</td>
<td>49</td>
</tr>
<tr>
<td>public_and_business</td>
<td>30</td>
<td>7</td>
<td>15</td>
<td>52</td>
</tr>
<tr>
<td>social_and_leisure</td>
<td>30</td>
<td>6</td>
<td>14</td>
<td>50</td>
</tr>
<tr>
<td>citywide</td>
<td>33</td>
<td>6</td>
<td>23</td>
<td>58</td>
</tr>
</tbody>
</table>

*Source*: calculated by the authors based on data from the SOVA Center for Information and Analysis and Rosstat.

### Table A3. Values of variables in model (2)

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interethnic_Crimes</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>size_of_town</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>national_republic</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>close_to_Moscow</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>age_structure</td>
<td>62</td>
<td>2</td>
<td>59</td>
<td>68</td>
</tr>
<tr>
<td>education</td>
<td>24</td>
<td>4</td>
<td>18</td>
<td>40</td>
</tr>
<tr>
<td>share_of_minorities</td>
<td>12</td>
<td>11</td>
<td>3</td>
<td>64</td>
</tr>
<tr>
<td>density</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>aggregate_income</td>
<td>10</td>
<td>0</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>unemployment</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>migration</td>
<td>489</td>
<td>780</td>
<td>9</td>
<td>6519</td>
</tr>
<tr>
<td>criminality</td>
<td>87</td>
<td>58</td>
<td>13</td>
<td>407</td>
</tr>
<tr>
<td>media</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>distance</td>
<td>9</td>
<td>33</td>
<td>0</td>
<td>225</td>
</tr>
<tr>
<td>poverty_line</td>
<td>13</td>
<td>4</td>
<td>7</td>
<td>32</td>
</tr>
</tbody>
</table>

*Source*: calculated by the authors based on data from the SOVA Center for Information and Analysis and Rosstat.
## Appendix B. Empirical results

### Table B1. Evaluation results of Models (1), (1*)

<table>
<thead>
<tr>
<th></th>
<th>Weighted LS (1)</th>
<th>Weighted LS (1*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>urban_environment</td>
<td>$-0.01^{***}$</td>
<td>$-0.02^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>housing</td>
<td></td>
<td>0.0004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.004)</td>
</tr>
<tr>
<td>streets</td>
<td></td>
<td>$-0.01^{**}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.004)</td>
</tr>
<tr>
<td>green_spaces</td>
<td></td>
<td>0.01***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.005)</td>
</tr>
<tr>
<td>public_and_business</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.004)</td>
</tr>
<tr>
<td>social_and_leisure</td>
<td></td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.004)</td>
</tr>
<tr>
<td>citywide</td>
<td>$-0.09^{***}$</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>(0.018)</td>
<td>(0.025)</td>
</tr>
<tr>
<td>size_of_town</td>
<td></td>
<td>$-0.19^{**}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.093)</td>
</tr>
<tr>
<td>national_republic</td>
<td>$-0.15^{***}$</td>
<td>$-0.04$</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.051)</td>
</tr>
<tr>
<td>close_to_Moscow</td>
<td>$-0.001$</td>
<td>$-0.02$</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>age_structure</td>
<td>$0.06^{***}$</td>
<td>$0.02^{**}$</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>education</td>
<td>0.004*</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.005)</td>
</tr>
<tr>
<td>share_of_minorities</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>density</td>
<td>0.05</td>
<td>0.12</td>
</tr>
<tr>
<td>aggregate_income</td>
<td>$-0.006$</td>
<td>$-0.03$</td>
</tr>
<tr>
<td></td>
<td>(0.085)</td>
<td>(0.158)</td>
</tr>
<tr>
<td>unemployment</td>
<td>$-0.0006$</td>
<td>$-0.001$</td>
</tr>
<tr>
<td></td>
<td>(0.018)</td>
<td>(0.028)</td>
</tr>
<tr>
<td>migration</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>criminality</td>
<td>$-0.0003$</td>
<td>$-0.001$</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>media</td>
<td>$0.06^{***}$</td>
<td>$-0.02$</td>
</tr>
<tr>
<td></td>
<td>(0.022)</td>
<td>(0.038)</td>
</tr>
</tbody>
</table>
Table B1. Continued

<table>
<thead>
<tr>
<th></th>
<th>Weighted LS (1)</th>
<th>Weighted LS (1*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>distance</td>
<td>0,00</td>
<td>0,001</td>
</tr>
<tr>
<td></td>
<td>(0,001)</td>
<td>(0,001)</td>
</tr>
<tr>
<td>poverty_line</td>
<td>-0,012*</td>
<td>-0,001</td>
</tr>
<tr>
<td></td>
<td>(0,006)</td>
<td>(0,018)</td>
</tr>
<tr>
<td>constant</td>
<td>-0,11</td>
<td>0,13</td>
</tr>
<tr>
<td></td>
<td>(0,769)</td>
<td>(1,404)</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0,59</td>
<td>0,43</td>
</tr>
</tbody>
</table>

Note: LS — Ordinary Least Squares (OLS); *** p < 0.01, ** p < 0.05, * p < 0.1.
Source: calculated by the authors.

Table B2. Results of evaluating Model (2) by the FE method

<table>
<thead>
<tr>
<th></th>
<th>FE</th>
</tr>
</thead>
<tbody>
<tr>
<td>size_of_town</td>
<td>1,02**</td>
</tr>
<tr>
<td></td>
<td>(0,434)</td>
</tr>
<tr>
<td>national_republic</td>
<td></td>
</tr>
<tr>
<td>close_to_Moscow</td>
<td></td>
</tr>
<tr>
<td>age_structure</td>
<td></td>
</tr>
<tr>
<td>education</td>
<td></td>
</tr>
<tr>
<td>share_of_minorities</td>
<td></td>
</tr>
<tr>
<td>density</td>
<td>-1,24***</td>
</tr>
<tr>
<td></td>
<td>(0,358)</td>
</tr>
<tr>
<td>aggregate_income</td>
<td>-2,93***</td>
</tr>
<tr>
<td></td>
<td>(0,863)</td>
</tr>
<tr>
<td>unemployment</td>
<td>0,28*</td>
</tr>
<tr>
<td></td>
<td>(0,142)</td>
</tr>
<tr>
<td>migration</td>
<td>-0,00</td>
</tr>
<tr>
<td></td>
<td>(0,0002)</td>
</tr>
<tr>
<td>criminality</td>
<td>-0,01*</td>
</tr>
<tr>
<td></td>
<td>(0,005)</td>
</tr>
<tr>
<td>media</td>
<td>0,49</td>
</tr>
<tr>
<td></td>
<td>(0,353)</td>
</tr>
<tr>
<td>poverty_line</td>
<td>0,04</td>
</tr>
<tr>
<td></td>
<td>(0,067)</td>
</tr>
<tr>
<td>constant</td>
<td>28,53***</td>
</tr>
<tr>
<td></td>
<td>(9,225)</td>
</tr>
<tr>
<td>Fixed time effects</td>
<td>+</td>
</tr>
<tr>
<td>Fixed area effects</td>
<td>+</td>
</tr>
<tr>
<td>LSDV-$R^2$</td>
<td>0,24</td>
</tr>
</tbody>
</table>

Note: FE — fixed effects model; *** p < 0.01, ** p < 0.05, * p < 0.1.
Source: calculated by the authors.
**Table B3.** Results of evaluating Model (2) by the OLS method

<table>
<thead>
<tr>
<th>Variable</th>
<th>LS</th>
<th>(p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>size_of_town</td>
<td>(-0.08)</td>
<td>(0.094)</td>
</tr>
<tr>
<td>national_republic</td>
<td>(-0.28)</td>
<td>(0.593)</td>
</tr>
<tr>
<td>close_to_Moscow</td>
<td>(-0.55^{***})</td>
<td>(0.114)</td>
</tr>
<tr>
<td>age_structure</td>
<td>(-0.31^{**})</td>
<td>(0.108)</td>
</tr>
<tr>
<td>education</td>
<td>(0.16^{***})</td>
<td>(0.035)</td>
</tr>
<tr>
<td>share_of_minorities</td>
<td>(-0.001)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>density</td>
<td>(0.06^{**})</td>
<td>(0.026)</td>
</tr>
<tr>
<td>aggregate_income</td>
<td>(2.06^{***})</td>
<td>(0.544)</td>
</tr>
<tr>
<td>unemployment</td>
<td>(0.11)</td>
<td>(0.122)</td>
</tr>
<tr>
<td>migration</td>
<td>(-0.00)</td>
<td>(0.0001)</td>
</tr>
<tr>
<td>criminality</td>
<td>(-0.01^{**})</td>
<td>(0.003)</td>
</tr>
<tr>
<td>media</td>
<td>(0.01)</td>
<td>(0.18)</td>
</tr>
<tr>
<td>poverty_line</td>
<td>(0.05)</td>
<td>(0.043)</td>
</tr>
<tr>
<td>distance</td>
<td>(-0.001)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>constant</td>
<td>(-1.43)</td>
<td>(3.867)</td>
</tr>
</tbody>
</table>

*Fixed time effects:*

| dt_2       | \(-0.06\) | (0.612) |
| dt_3       | \(-0.61\) | (0.7)   |
| dt_4       | \(-1.1\)  | (0.748) |
| dt_5       | \(-2.59^{***}\) | (0.687) |
| dt_6       | \(-3.42^{***}\) | (0.712) |
**Table B3.** Continued

<table>
<thead>
<tr>
<th></th>
<th>LS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$dt_7$</td>
<td>$-3.11^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.843)</td>
</tr>
<tr>
<td>$dt_8$</td>
<td>$-3.68^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.837)</td>
</tr>
<tr>
<td>$dt_9$</td>
<td>$-4.58^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.853)</td>
</tr>
<tr>
<td>$dt_{10}$</td>
<td>$-4.7^{****}$</td>
</tr>
<tr>
<td></td>
<td>(0.902)</td>
</tr>
<tr>
<td>$dt_{11}$</td>
<td>$-5.04^{***}$</td>
</tr>
<tr>
<td></td>
<td>(0.901)</td>
</tr>
<tr>
<td>$dt_{12}$</td>
<td>$-5.13^{***}$</td>
</tr>
<tr>
<td></td>
<td>(1.005)</td>
</tr>
<tr>
<td>$dt_{13}$</td>
<td>$-5.32^{***}$</td>
</tr>
<tr>
<td></td>
<td>(1.067)</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.17</td>
</tr>
</tbody>
</table>

*Note:* LS — Ordinary Least Squares (OLS); $^{***} p < 0.01$, $^{**} p < 0.05$, $^{*} p < 0.1$.  
*Source:* calculated by the authors.
Assessing the impact of institutions on economic growth in the BRICS countries

Ayushi Tiwari,*
Ramjas College, University of Delhi (India)

Tridisha Bharadwaj,
Ramjas College, University of Delhi (India)

Abstract
This study examines the impact of institutional quality on economic performance in the BRICS countries for the period from 2002 to 2019. The panel data study was estimated using pooled OLS and a fixed effect model. The study employed six institutional quality indicators (Worldwide Governance Indicators) which included voice and accountability, political stability and absence of violence/terrorism, government effectiveness, regulatory quality, rule of law, and control of corruption. The study also controlled for conventional sources of growth, i.e., human capital, physical capital, government expenditure, and inflation. All of these factors were positive and significant in our study. The findings also reveal that government effectiveness, regulatory quality and control of corruption had a positive and significant impact on economic growth in the BRICS countries, whereas other institutional variables turned out to be insignificant.

Keywords: BRICS, economic growth, economic development, institutions, panel data, regression analysis.

JEL: C01, C13, O43, O10.

Introduction
Economists have long argued about what affects economic growth. There are still gaps in the literature on the determinants of economic growth. Poor human development, low labor productivity, low standard of living and other factors severely impede a country’s economic performance. In a similar vein, the government and its institutions have a critical role to play in enhancing a country’s economic growth.
Before proceeding any further, it is imperative to understand what we mean by institutions and how this affects a country's performance. North (1981) defines institutions as “a set of rules, compliance, procedures, and moral and ethical behavioral norms designed to constrain the behavior of individuals in the interests of maximizing the wealth or utility of principals.” Sala-i-Martin (2002), on the other hand, states that institutions should encompass enforcement of contracts, protection of property rights, perceptions that the judiciary system is predictable and effective, transparency of the public administration, control of corruption, and pro-market regulations. It is particularly difficult to assess institutional quality in an empirical study due to the differences in definitions and measurements. However, the current study attempts to closely follow (Kaufmann et al., 2008) reports on Worldwide Governance Indicators which are useful for broad cross-country and over-time comparisons of the quality of institutions and governance.

The idea of exploring the relationship between institutional quality and economic growth has not emerged recently. There is already a rich body of empirical and theoretical studies that inquire into this relationship (Rodrik et al., 2004; Alexiou et al., 2014; Valeriani & Peluso, 2011). In addition, studies have also attempted to investigate the relationship of institutional quality with poverty and income inequality (Chong & Gradstein, 2004; Hasan et al., 2007). Moreover, many other studies have tried to inspect the relationship of economic growth with specific indicators of institutional quality, such as corruption, rule of law, quality of contract enforcement, property rights (see, for example, Knack and Keefer (1995b), Mauro (1995), Vijayraghavan and Ward (2001)).

The general consensus is that improvement in the quality of institutions will inevitably lead to a rise in economic growth. The literature provides strong evidence supporting the concept that institutions are very important for a country’s performance. If there is convincing evidence that poor political and economic institutions significantly impede progress, policymakers may recommend actions to strengthen institutions in specific ways or encourage more pertinent political structures (Aron, 1996).

From an empirical standpoint, there is a lack of data regarding institutional quality. It is even more so because analyses on institutional quality use subjective measures, including voice and accountability, corruption, freedom of expression, and others. But the availability of quantitative measures of institutional quality (for example, from the World Bank) has contributed to the growth of literature that focuses on the impact of institutions on economic growth and average income. However, empirical studies assessing the link between different aspects of institutional quality and economic growth in emerging market economies are still limited. The BRICS countries constitute the five major developing economies, namely Brazil, Russia, India, China and South Africa. The BRICS have experienced remarkable economic progress. In the next 40 years, they may be larger than the economies of the United States, Japan, and Europe combined. Furthermore, investments in the BRICS countries are growing rapidly. These nations account for 42% of the world’s population, with a combined population of almost 3 billion people. Such a large population implies a great potential for development. Apart from this, these countries do face such problems as political imperfection, massive corruption and poor institutional quality.
In this context, the study attempts to make a contribution to the existing body of literature by focusing on examining the link between institutions and economic growth in the BRICS countries.

Moreover, the study attempts to identify specific indicators of institutional quality that are more critical in determining economic growth in the BRICS countries. Previous studies state that good institutional quality leads to higher economic growth and, as a result, higher economic growth requires more refined and quality institutions. Thus, the study conducts an empirical analysis to quantify the impact of institutional quality on economic growth in selected emerging market economies, i.e. the BRICS countries, over the period 2002–2019 using a fixed effects model.

The structure of the paper is as follows. The next section provides an in-depth discussion of the relationship between institutions and economic growth. Section 2 presents an overview of the literature used for our work. Section 3 explains the econometric model. Section 4 presents the dataset used for our analysis. Section 5 offers the results, followed by a detailed discussion of our analysis. The last section is a description of possibilities for further study. Appendix and Notes can be found at the end of the paper.

1. Relationship between institutions, institutional quality and economic growth

The work of such academics as Douglas North, Robert Fogel, Daron Acemoğlu and others have had an important impact on economists’ ideas about governance and institutions and their relationship with economic performance. But what are institutions? In fact, what do we mean by institutional quality and what is its linkage to economic growth? This section attempts to answer these questions.

From a theoretical standpoint, one can view institutional quality as an aggregate index that covers a multitude of attributes, such as protection of property rights, perception of the judiciary system as predictable and effective, transparency of public administration, and so on, without considering every single aspect related to institutions. Most scholars follow this approach to examine the relationship between institutions and economic growth. But what makes the role of institutions so critical for a nation’s economic growth? North (1990) asserts that institutions play a vital role in determining the structure of a society. Hasan et al. (2007) note that countries are rich or poor depending on whether their institutional constraints define a set of payoffs to political and economic activities that encourage productive activity. In other words, when institutions are not robust, they allow organizations, including firms, trade unions, political parties, business associations, etc., to engage in “unproductive” activities.

Acemoğlu et al. (2005), Knack and Keefer (1995), Rodrik et al. (2004) conclude that the contribution of institutions to determining long-run causes of economic growth is more significant than other variables. We subdivide institutions into “economic institutions” and “political institutions.” Economic institutions differ from political institutions in how they influence the structure of incentives in society. Put differently, economic
institutions are engaged in allocating resources and determining the growth potential of a country, while political institutions determine constraints and incentives within the political spectrum. Both types of institutions support each other to augment economic growth and development.

In this setting, the institutional framework in developing countries allows for more redistributive than productive activities, which in fact restrict opportunities rather than expand them. North (1990) states: “They seldom induce investment in education that increases productivity.” Thus, institutions influence not only capital accumulation but also the “process of converting this capital into output” (Hasan et al., 2007). In developing economies, the effect of establishing quality institutions in terms of the rule of law or the practice of democracy on economic growth is extensively debated in the development literature.

It is argued that the current institutional quality in developing nations provides for a weak incentive to augment growth, which results in them continuing to be poor. Hasan et al. (2007) state that such market economies not only require a “dynamic” private sector to emerge but also need a “modicum of equity” to function effectively. Rodrik (2000) poignantly points out the importance of institutions that provide stabilizing and regulatory functions, as well as provide social assurance in order for markets to thrive. Russia, for instance, failed after privatization due to the lack of any regulatory framework. The same thing followed during the Asian financial crisis due to the lack of financial regulation.

The study uses the World Governance Indicators1 produced by the World Bank. The dataset contains six aspects of institutional quality. These are control of corruption, government effectiveness, political stability and absence of violence/terrorism, regulatory quality, the rule of law, and voice and accountability. The aggregate indicators are based on several hundred individual underlying variables taken from a wide variety of existing data sources. The data reflect the views on governance of survey respondents and experts from public, private, and non-governmental organizations worldwide and allow for meaningful cross-country and over-time comparisons.

2. Literature review

Contrary to the popular opinion that factors such as capital stock and labor have a significant impact on economic growth, many pure institutionalists believe that institutions and institutional quality are the only basic determinants of economic behavior and growth.

According to the literature on institutional economics, institutional quality is arguably one of the most important factors of development (Acemoğlu et al., 2003; Rodrick et al., 2002). The quality of institutions, such as the rule of law, a good bureaucratic structure, and corruption, is critical to understanding the growth of a country. High institutional quality has been proposed as a driver of economic growth through motivating economic

---

1 The methodology by which World Governance Indicators are constructed can be viewed at https://info.worldbank.org/governance/wgi/Home/Documents
activities such as consumption and investment, more efficiently allocating resources, and promoting freedom of choice (Nguyen et al., 2018).

In their article on creative destruction and economic growth and the role of various institutions in the process of economic restructuring and growth, Caballero and Hammour (2000) discussed that an effective institutional structure was critical for the introduction of new technologies, redistribution of labor forces and keeping up with global economic developments. According to Rodrik et al. (2002), the quality of formal institutions is a prominent factor for understanding differences in income levels between countries. Scully (1988), while examining informal institutions, concluded that they were a vital source of information about the differences in real per capita growth rates between countries. Valeriani and Peluso (2011) examined the institutional framework through which economic growth occurs and growth differences among countries. The study concluded that the quality of economic institutions had a positive impact on the growth and development of a nation.

There are significant theoretical and empirical studies of the hypothesis that factors such as capital stock, human capital, government expenditure, inflation etc. have a significant impact on growth. Arayama and Miyoshi (2004) and Chow (1993) found a positive relationship between investments in physical capital and growth in China. Physical capital plays a key role in facilitating an economy’s development. At a given level of GDP, a higher ratio of human capital to physical capital leads to rapid growth due to two factors. First, high human capital eases the introduction of advanced technologies in developed countries. Second, it is more difficult to adjust human capital than physical capital (Barro, 2001; Glaeser, 1994; Goetz, 1996; Bassanini & Scarpetta, 2002).

In many empirical studies, government expenditure is a determinant of growth. These studies have yielded conflicting results. Ram (1986) found that government expenditure had a significant positive effect on growth, particularly in developing countries, but total government spending had a negative effect on growth. Bose et al. (2007) argued that government investment and education expenditures contributed to growth. Moreno-Dodson (2012) contemplated that the net effect of public spending on growth was positive in a sample of seven fast-growing developing countries.

Fischer (1983), taking an average of 54 countries over two different time periods, found a significant negative relationship between growth and inflation rate. Barro (1995) suggested the same for about 100 countries between 1960 and 1990. He also argued that statistically meaningful results emerged only when high-inflation events were included in the sample. Although inflation had a minor impact on growth, the long-term repercussions on living standards were significant.

3. Econometric model and estimation

The study aims to examine the impact of institutions on economic growth in the five BRICS nations. To find out the relationship between institutions and economic growth, the following model was estimated:
\[ \ln Y_{it} = \beta_0 + \beta_1 \ln H_{it} + \beta_2 \ln K_{it} + \beta_3\text{GOVEX}_{it} + \beta_4 CPI_{it} + \beta_5 INS_{it} + \varepsilon_{it} \] (*), \hspace{1cm} (1)

where: \( i = 1,2,\ldots,5 \), \( t = 1,2,\ldots,18 \), \( j = 1,2,\ldots,6 \).

Here \( i \) refers to the number of cross-sectional subjects in the panel dataset, \( t \) refers to the time dimension of the panel dataset, and \( j \) refers to the various dimensions of institutional quality which have been considered in this study. \( \beta_1, \beta_2, \beta_3, \beta_4, \beta_5 \) represent the regression coefficients of the model. The control variables chosen along with data sources are mentioned in Table 1.

The estimation methods used in this study are pooled OLS estimation and fixed effects estimation. Given that there is a realistic expectation of heterogeneity among the BRICS nations, intuitively, the pooled OLS estimation method will not be the most appropriate estimation method because lumping together different countries may result in subsuming the individuality of different countries (Gujarati, 2014). Moreover, it does not appear that the random effects estimation method is the appropriate method because we are working with a small panel, and cross-sectional units in our sample aren’t drawn at random. Additionally, “even if it is assumed that the underlying model is pooled or random, the fixed effects estimators are always consistent” (Gujarati, 2014). Hence, we believe that the fixed effects method is the most appropriate estimating method for this study. The econometric model was estimated by both methods. The decision regarding the most appropriate estimation method(s) was made based on the F-test (see Appendix A4).

The study makes use of six dimensions of institutional quality. Data on different dimensions of institutional quality were used alternately to evaluate the econometric model given in equation (1).\(^2\) This ensures two things. First, the problems related to imperfect multicollinearity are avoided, since it is only reasonable to expect that the data on different aspects of institutional quality are correlated with each other. This expectation is borne out by reality (see Appendix A2). Second, the dimensions of institutional quality, which are more important for determining economic growth in the BRICS countries, can be identified conveniently and accurately. Additionally, when different dimensions of institutional quality were taken into consideration individually, all six models were free from heteroskedasticity.

4. Data sources

This study uses a panel dataset that was compiled from larger datasets provided by the World Bank, UNDP. The compiled dataset includes data on BRICS members - the five most important economies in the world (Brazil, Russia, India, China, and South Africa). The data was compiled from 2002 to 2019 as per data availability. The period was limited to the years from 2002 to 2019 due to huge gaps in data on the chosen variables, especially in the case of China. In order to avoid the same, the chosen period was taken up in the study to provide an accurate understanding of the topic.

\(^2\) Our dataset includes 5 nations, R allows users to run random effects estimation only if the equation contains 5 variables including the intercept in the model. However, our regression equation contains 6 variables including the intercept. Hence random effect model has not been estimated.
A description of the data on the dependent variable and control variables is given in Table 1.

Table 1. Description of data on the dependent and independent variables

<table>
<thead>
<tr>
<th>Conceptual variable</th>
<th>Observable variable</th>
<th>Classification</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total output/ Income (Y)</td>
<td>GDP at constant 2010 prices (USD)</td>
<td>Dependent variable</td>
<td>World Bank</td>
</tr>
<tr>
<td>Human capital (H)</td>
<td>Education index</td>
<td>Control variable</td>
<td>United Nations Development Program (UNDP)</td>
</tr>
<tr>
<td>Physical capital (K)</td>
<td>Gross capital formation at constant 2010 prices (USD)</td>
<td>Control variable</td>
<td>World Bank</td>
</tr>
<tr>
<td>Government expenditure (GOVEX)</td>
<td>General government final consumption expenditure (% of GDP)</td>
<td>Control variable</td>
<td>World Bank</td>
</tr>
<tr>
<td>(CPI)</td>
<td>Inflation, consumer prices (annual %)</td>
<td>Control variable</td>
<td>World Bank</td>
</tr>
</tbody>
</table>

*Source:* compiled by the author based on data provided by the United Nations Development Program and World Development Indicators.

This study took into account data on all six dimensions of institutional quality offered by World Governance Indicators. Table 2 describes the data on dimensions of institutional quality. These are estimates ranging from −2.5 to +2.5, with higher values representing better governance performance.

Table 2. Description of data on various aspects of institutional quality

<table>
<thead>
<tr>
<th>Dimensions of institutional quality</th>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice and accountability (VA)</td>
<td>Independent variable</td>
<td>It measures perceptions of the extent to which a country’s citizens are able to participate in the election of their government, as well as freedom of expression, freedom of association, and freedom of the media</td>
</tr>
<tr>
<td>Political stability and absence of violence/terrorism (PT)</td>
<td>Independent variable</td>
<td>It measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism</td>
</tr>
<tr>
<td>Government effectiveness (GE)</td>
<td>Independent variable</td>
<td>It captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressure, the quality of policy formulation and implementation, and the credibility of the government’s commitment to such policies</td>
</tr>
</tbody>
</table>
Table 2. Continued

<table>
<thead>
<tr>
<th>Dimensions of institutional quality</th>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulatory quality (RQ)</td>
<td>Independent variable</td>
<td>It captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote the development of the private sector</td>
</tr>
<tr>
<td>Rule of law (RL)</td>
<td>Independent variable</td>
<td>It captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and, in particular, the quality of contract enforcement, property rights, police and courts, as well as the likelihood of crime and violence</td>
</tr>
<tr>
<td>Control of corruption (CC)</td>
<td>Independent variable</td>
<td>It captures perceptions of the extent to which public power is exercised for private gain, including both small and major forms of corruption, as well as “seizure” of the state by elites and private interests</td>
</tr>
</tbody>
</table>

Source: compiled by the author based on information provided by World Governance Indicators.

5. Estimation results and their interpretation

This section presents results based on the pooled OLS and fixed effects estimation methods. Based on the results of the F-test, the correct estimation method(s) was determined.

Descriptive statistics of the compiled dataset and the results of the F-test can be found in the Appendix (see Appendix A3 and Appendix A4). The estimation results of Equation (1) based on the different estimation methods are given in Tables 3 and 4.

Table 3. Pooled OLS estimation results

<table>
<thead>
<tr>
<th>Regressor</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.6276</td>
<td>4.1799</td>
<td>5.2089</td>
<td>5.2568</td>
<td>5.0458</td>
<td>4.7372</td>
</tr>
<tr>
<td></td>
<td>(0.000)***</td>
<td>(0.000)***</td>
<td>(0.000)***</td>
<td>(0.000)***</td>
<td>(0.000)***</td>
<td>(0.000)***</td>
</tr>
<tr>
<td>lnH</td>
<td>-0.0146</td>
<td>-0.3607</td>
<td>-0.2789</td>
<td>-0.4145</td>
<td>-0.4274</td>
<td>-0.3973</td>
</tr>
<tr>
<td></td>
<td>(0.9257)</td>
<td>(0.0217)*</td>
<td>(0.0261)*</td>
<td>(0.0040)**</td>
<td>(0.0100)*</td>
<td>(0.0186)*</td>
</tr>
<tr>
<td>lnK</td>
<td>0.8823</td>
<td>0.8414</td>
<td>0.8173</td>
<td>0.8023</td>
<td>0.8171</td>
<td>0.8262</td>
</tr>
<tr>
<td></td>
<td>(0.000)***</td>
<td>(0.000)***</td>
<td>(0.000)***</td>
<td>(0.000)***</td>
<td>(0.000)***</td>
<td>(0.000)***</td>
</tr>
<tr>
<td>GOVEX</td>
<td>0.0490</td>
<td>0.0678</td>
<td>0.0538</td>
<td>0.0669</td>
<td>0.0544</td>
<td>0.0594</td>
</tr>
<tr>
<td></td>
<td>(0.000)***</td>
<td>(0.000)***</td>
<td>(0.000)***</td>
<td>(0.000)***</td>
<td>(0.000)***</td>
<td>(0.000)***</td>
</tr>
</tbody>
</table>
Table 3. Continued

<table>
<thead>
<tr>
<th>Regressor</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPI</td>
<td>0.0094</td>
<td>0.0078</td>
<td>0.0009</td>
<td>0.0075</td>
<td>0.0079</td>
<td>0.0081</td>
</tr>
<tr>
<td></td>
<td>(0.0377)*</td>
<td>(0.1095)</td>
<td>(0.8233)</td>
<td>(0.0903)</td>
<td>(0.0978)</td>
<td>(0.0973)</td>
</tr>
<tr>
<td>VA</td>
<td>0.0777</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.0048)**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PT</td>
<td>-</td>
<td>-0.1141</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0459)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GE</td>
<td>-</td>
<td>-</td>
<td>-0.2712</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0000)***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.2592</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.0001)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RL</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.1428</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.0211)*</td>
<td></td>
</tr>
<tr>
<td>CC</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.1015</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.0606)</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.97949</td>
<td>0.9784</td>
<td>0.9835</td>
<td>0.9809</td>
<td>0.9788</td>
<td>0.9783</td>
</tr>
</tbody>
</table>

Note: The values in parentheses represent the p-value; *** represents significance at the 1 percent level of significance, ** represents significance at the 5 percent level of significance, and * represents significance at the 10 percent level of significance.

Source: calculated by the author based on the compiled dataset.

Based on the results of the statistical test (see Appendix A4), it can be concluded that the fixed effects estimation approach is the best suitable estimation method for this study. This also supports our intuitive reasoning discussed in Section 3. As a result, the findings of the estimations shown in Table 4 are all that is required for statistical inference and interpretation.

Table 4. Fixed effects estimation results

<table>
<thead>
<tr>
<th>Regressor</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnH</td>
<td>1.0932</td>
<td>1.1234</td>
<td>1.0690</td>
<td>1.1984</td>
<td>1.1581</td>
<td>1.1796</td>
</tr>
<tr>
<td></td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
</tr>
<tr>
<td>lnK</td>
<td>0.5401</td>
<td>0.5314</td>
<td>0.5174</td>
<td>0.5231</td>
<td>0.5239</td>
<td>0.5162</td>
</tr>
<tr>
<td></td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
</tr>
<tr>
<td>GOVEX</td>
<td>0.0277</td>
<td>0.0286</td>
<td>0.0313</td>
<td>0.0376</td>
<td>0.0269</td>
<td>0.0402</td>
</tr>
<tr>
<td></td>
<td>(0.0008)***</td>
<td>(0.0005)***</td>
<td>(0.0000)***</td>
<td>(0.0000)***</td>
<td>(0.0009)***</td>
<td>(0.0000)***</td>
</tr>
<tr>
<td>CPI</td>
<td>-0.0051</td>
<td>-0.0049</td>
<td>-0.0047</td>
<td>-0.0061</td>
<td>-0.0048</td>
<td>-0.0040</td>
</tr>
<tr>
<td></td>
<td>(0.0178)*</td>
<td>(0.0168)*</td>
<td>(0.0065)**</td>
<td>(0.0021)***</td>
<td>(0.0170)*</td>
<td>(0.0263)*</td>
</tr>
</tbody>
</table>
The results shown in Table 4 can be interpreted as follows. In the BRICS countries, a one percent increase in physical capital leads to an increase in total output/income by an average of 0.52–0.54%. Likewise, a one percent increase in human capital leads to an increase in total output/income by an average of 1.07–1.2%. A one unit increase in government expenditure leads to an increase in total output/income by an average of 2.7–4.02%. On the other hand, a one unit increase in inflation leads to a decrease in total output/income by an average of 0.4–0.6%. Partial slope coefficients associated with the natural log of physical capital and human capital, government expenditure and inflation are highly statistically significant in all six regression equations.

On the other hand, the coefficients for different indicators of institutional quality have different interpretations. In the BRICS countries, an increase by one standard deviation unit in regulatory quality, control of corruption, government effectiveness, the rule of law, and political stability and absence of violence leads to an increase in total output/income by an average of 12, 16, 17, 9 and 3%, respectively. However, an increase by one standard deviation unit in voice and accountability leads to an average decrease in total output/total income by 2%. All indicators of institutional quality turned out to be highly statistically significant, except for the rule of law, voice and accountability, and political stability and absence of violence.

According to the findings of Kossele et al. (2017), there is a positive substantial relation between government effectiveness and economic growth. Our results help reinforce the same statement. A nation with a smooth-running government develops effective policy...
making, thereby accelerating growth and development for all its citizens. Additionally, regulatory quality and economic growth are expected to be positively linked (Kaufmann, et al., 2002). The sign of this coefficient in our study corresponds to the a priori expectation. The improved regulatory quality creates incentives for both public and private sectors, which as a result contributes to boosting the growth of a nation.

A popular theory devised by Sirowy and Inkeles in 1990 states that if a country achieves a higher level of democracy before reaching the threshold level of economic growth, it may face difficulties in achieving a higher level of economic growth. Put it differently, developing countries struggle to achieve higher growth as they tend to satisfy the demands of everyone in the short run. On the other hand, authoritarian states tend to achieve greater economic growth due to their better ability to control resources and implement policies. Interestingly, the coefficient of voice and accountability turned out to be negative and insignificant. Our study includes China and South Africa, which have been largely authoritarian for a long time and the repercussions of this are felt decades later.

Effective public governance ensures the adoption of laws and their accessibility to citizens. As a result, this helps to improve the economic growth of the nation (Burgess, 2012). The existence of the rule of law in a country provides stability, which will undoubtedly increase investments because investors will feel protected by the implementation of laws by the judiciary, which will ensure full justice. Although the rule of law was insignificant, the sign of this coefficient corresponds to our a priori expectation. The coefficient for political stability and absence of violence/terrorism turned out to be insignificant, but the sign is positive. Younis et al. (2008) note that a stable political environment in a country not only increases the accumulation of human capital and physical capital but also stimulates the growth process.

One more thing should be noted here: achieving a one standard deviation unit increase/decrease in any of the dimensions of institutional quality is of great importance. Such results are the culmination of ideas formed over decades. This explains why a change in the unit of measurement in any dimension of institutional quality has a greater impact on total output/total income than a change in the unit of measurement in any of the control variables: physical capital, human capital, government expenditure, and inflation.

6. Conclusion

The study manages to identify some of the most critical dimensions pertaining to the empirical relationship between institutional quality and economic growth in the BRICS countries. Most countries devise policies taking into account factors such as capital stock, human capital, government expenditure, inflation, etc. with the objective of achieving higher growth and development. However, this research suggests that the impact of institutions on economic growth may be as important as the influence of other conventional determinants.

According to this study, other control variables, such as physical capital, human capital, and government expenditure, show a positive relationship with the real per capita
GDP growth. On the other hand, inflation shows a negative relationship with the real per capita GDP growth. From the above results, it is obvious that the impact of institutions on economic growth is higher than the influence of other variables, such as physical capital, human capital, government expenditure and inflation.

Our findings reveal that control of corruption, regulatory quality and government effectiveness are the most important dimensions of institutional quality that influence economic growth. Control of corruption shows a significant positive relationship with economic growth at the 1% significance level. Similarly, both government effectiveness and regulatory quality show a significant positive relationship with economic growth at the 1% significance level.

Interestingly, control of corruption turned out to be positive, in contrast to the popular belief. The discussion section above elaborates on this in more detail. China is part of our sample and is notorious for fostering rapid growth despite rampant corruption. Moreover, voice and accountability is another dimension that turned out to be negative. This highlights that some socially important factors, such as democracy and freedom, do not significantly affect economic growth.

This study concludes that there is a significant relationship between institutions and economic growth in these emerging market economies. Six different dimensions of institutional quality are important determinants of growth in the context of BRICS. The study suggests that the countries should improve these institutional structures to promote higher growth and development. Since institutions have been found to be a significant determinant of economic growth in all sampled countries, the study recommends the development of effective institutions for enhancing economic growth in these countries.

7. Further research proposals

To obtain effective estimators, it is necessary to evaluate endogeneity and simultaneity. This can be done by using instrumental variables. Hence, the model developed in our study can be refined by using instrumental variables. It is very difficult to find good instruments that correlate with exogenous variables, but not with the dependent variable. The literature suggests some possible instruments that can be used. Mauro (1995) argues that the index of ethnic fractionalization is a valid instrument for institutional variables. Acemoğlu et al. (2001) use settler mortality as an indicator of institutions which is available only for 56 countries — a country’s high settler mortality is a sign of weak institutions. According to Easterly and William (2002), tropical weather, pathogens, and crops have an indirect impact on development, which then affects institutions. Colonial provenance, assessed by the percentage of the population speaking one of the main European languages, was used as an instrument by Hall and Jones (1999).

We were unable to add instrumental variables due to a lack of data (in a continuous interval for our sample). Once this is taken into account, the estimators will have more precise values. Therefore, the authors urge future researchers to take these factors into consideration in order to provide a comprehensive understanding of the relationship between institutions and economic growth in countries.
References


Appendix

A1. Scatter plot of lnY and different explanatory variables
Assessing the impact of institutions on economic growth in the BRICS countries

A2. Correlation matrix for different aspects of institutional quality

<table>
<thead>
<tr>
<th></th>
<th>VA</th>
<th>PT</th>
<th>GE</th>
<th>RQ</th>
<th>RL</th>
<th>CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>VA</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PT</td>
<td>0.1776</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GE</td>
<td>0.1782</td>
<td>0.5346</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ</td>
<td>0.5239</td>
<td>0.7148</td>
<td>0.6539</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RL</td>
<td>0.7335</td>
<td>0.3024</td>
<td>0.6097</td>
<td>0.5373</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>CC</td>
<td>0.6208</td>
<td>0.6555</td>
<td>0.7400</td>
<td>0.8256</td>
<td>0.7995</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: calculated by the author based on the compiled dataset.

A3. Descriptive statistics of the compiled dataset

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnY</td>
<td>28.12478</td>
<td>28.1675</td>
<td>0.935634</td>
<td>26.37224</td>
<td>30.07337</td>
</tr>
<tr>
<td>lnH</td>
<td>−0.46625</td>
<td>−0.43541</td>
<td>0.177863</td>
<td>−0.94161</td>
<td>−0.1948</td>
</tr>
<tr>
<td>lnK</td>
<td>26.78219</td>
<td>26.74064</td>
<td>1.194982</td>
<td>24.49177</td>
<td>29.26222</td>
</tr>
<tr>
<td>CPI</td>
<td>5.933053</td>
<td>5.292291</td>
<td>3.573</td>
<td>−0.73197</td>
<td>15.78873</td>
</tr>
<tr>
<td>VA</td>
<td>−0.19885</td>
<td>0.41349</td>
<td>0.903644</td>
<td>−1.74897</td>
<td>0.715737</td>
</tr>
<tr>
<td>PT</td>
<td>−0.56409</td>
<td>−0.51219</td>
<td>0.440802</td>
<td>−1.51335</td>
<td>0.329845</td>
</tr>
<tr>
<td>GE</td>
<td>0.032914</td>
<td>−0.00623</td>
<td>0.302806</td>
<td>−0.50049</td>
<td>0.692696</td>
</tr>
<tr>
<td>RQ</td>
<td>−0.09925</td>
<td>−0.21437</td>
<td>0.327086</td>
<td>−0.52078</td>
<td>0.804242</td>
</tr>
<tr>
<td>RL</td>
<td>−0.27265</td>
<td>−0.19176</td>
<td>0.352807</td>
<td>−0.97012</td>
<td>0.255048</td>
</tr>
<tr>
<td>CC</td>
<td>−0.34604</td>
<td>−0.3551</td>
<td>0.398238</td>
<td>−1.13205</td>
<td>0.568106</td>
</tr>
</tbody>
</table>

Source: calculated by the author based on the compiled dataset.
A4. Statistical tests to determine the appropriate estimation method(s) F-Test (Pooled OLS v/s Fixed Effects)

Ho: Both the pooled OLS method and fixed effects method give consistent estimators.
H1: Fixed effects method gives consistent estimators.

Table A4. Results of F-tests

<table>
<thead>
<tr>
<th>Dimension of institutional quality in the regression model</th>
<th>F-Tests statistics</th>
<th>Appropriate estimation method</th>
</tr>
</thead>
<tbody>
<tr>
<td>VA</td>
<td>115.26 (0.0000)***</td>
<td>Fixed Effects</td>
</tr>
<tr>
<td>PT</td>
<td>124.18 (0.0000)***</td>
<td>Fixed Effects</td>
</tr>
<tr>
<td>GE</td>
<td>129.85 (0.0000)***</td>
<td>Fixed Effects</td>
</tr>
<tr>
<td>RQ</td>
<td>118.09 (0.0000)***</td>
<td>Fixed Effects</td>
</tr>
<tr>
<td>RL</td>
<td>123.63 (0.0000)***</td>
<td>Fixed Effects</td>
</tr>
<tr>
<td>CC</td>
<td>161.02 (0.0000)***</td>
<td>Fixed Effects</td>
</tr>
</tbody>
</table>

Note: The values in parentheses represent the *p*-value; *** represents significance at the 1 percent level of significance.

Source: calculated by the author based on the compiled dataset.
The impact of world oil and food price shocks on the interdependence of Brazil and Russia: SVAR-DCC-GARCH model

Samkelisiwe Bhebhe,*
Faculty of Commerce, National University of Science and Technology (Zimbabwe)

Ian Ndlovu,
Faculty of Commerce, National University of Science and Technology (Zimbabwe)


Abstract

This study seeks to identify the extent to which global oil and food price volatilities affected the interdependence of the Brazilian and Russian economies in the period from 1996 to 2021. The ARCH/GARCH framework was used to model the volatility of oil and food prices. The Structural Vector Autoregressive (SVAR) approach was used to ascertain the sensitivity of key economic indicators to oil and food shocks. The Impulse Response Function (IRF) was used to trace short-term effects over a period of 12 months. Subsequently, the multivariate dynamic conditional correlation DCC-GARCH model, created by Engle & Sheppard (2001), was used to model time-varying correlations of paired macroeconomic variables. This study contributes to the empirical literature in two fundamental ways. Firstly, it pairs the two largest oil and food producers in the BRICS bloc. Secondly, unlike some earlier studies, the applied methodology ensures the effectiveness of the results by using stationary time series data. The results show that Brazil and Russia have long-run spillover effects for all macroeconomic variables in response to both oil and food price shocks. Furthermore, money supply and exchange rate variables exhibited declining positive correlation coefficients during the global financial crisis of 2008–2009, but peaked in early 2020 due to the Covid-19 pandemic. As a corollary of the main findings, the researchers recommend that investors should diversify their portfolios beyond these two economies in order to minimize the risk of contagion during severe global crises.

**Keywords:** oil price volatility, food price volatility, SVAR, IRF, DCC-GARCH, Brazil, Russia, money supply.

**JEL:** F45, Q02, C32.

* E-mail of the corresponding author: samkelisiwe.bhebhe@nust.ac.zw
Introduction

The past three decades have been characterized by seemingly more significant than expected swings in energy and agricultural markets worldwide in terms of demand and price. On the downside, energy markets were affected by civil unrest in the oil-rich countries of the Middle East and price wars among top producers. Widespread effects of climate change, such as heat waves, tropical cyclones, severe frosts and droughts, led to a reduction in global food output, while the global population is on the rise, reaching 7.8 billion people in 2021 (World Bank, 2021).

The BRICS countries (Brazil, Russia, India, China and South Africa) are perfectly interwoven into the global energy and agricultural matrix not only as major consumers, but also as major producers. The BRICS countries account for approximately 42% of the world’s population (World Bank, 2021) and therefore present a force to be reckoned with in the trade markets, particularly in light of the trade agreements within the bloc.

Hamilton (2009) finds a strong correlation between the 2008 financial crisis and crude oil prices. Trujillo-Barrera et al. (2012) provide evidence that 10–20% fluctuations in corn and ethanol prices were explained by crude oil price volatility and that this variability increased to 45% during the US financial crisis. This shows that there is a delicate yet strong relationship between energy and food markets, and movements in these markets have a direct bearing on the development of the economy and the economic bloc for that matter.

Brazil. According to the World Bank (2021), the Brazilian population has grown from 167 million in 1997 to 212 million in 2021. Oil consumption peaked in 2014 at 2.7 million barrels per day and gradually decreased to 2.39 million barrels per day in 2019, which is approximately 650% more than the consumption rate of 1965 (BP Statistical Review, 2020). Economic growth slumped between 1998 and 2002, which coincided with the fall in global oil prices. Brazil runs a free-market economy and is rich in natural resources, including forests, rich soils and abundant water supplies. Net FDI inflows were recorded at US$ 2.39 billion in 2010 and rose to US$102.43 in 2011, compared to the meagre $4.86 billion in 1995 (World Bank, 2021). Part of the growth in FDI from 2010 to date can be directly attributed to joining the BRICS union and increased levels of integration with the world’s top three emerging markets.

Brazil has significantly reduced energy imports and is the world’s second largest producer of ethanol fuel accounting for 24% of global output. Further, the country has a developed hydropower infrastructure due to the abundance of water and it is the world’s third largest producer of hydropower. Nuclear power plants have been operating in the country since 1985. According to the BP Statistical Review (2020), Brazil’s crude oil production reached a historic level of 2.5 million barrels a day in 2015 and further increased to 2.8 million barrels in 2019. However, this is mostly heavy crude oil, hence the country still needs to import light crude oil. While Brazil’s energy production grew by 4.2% in 2015, consumption fell by 1.6% in the same period, representing the first decline since 2009, and this is consistent with falling economic data.

Brazil’s productive capacity has allowed it to rise from 16th to 5th position in global food production, turning a new page as a former importer and now a leading exporter.
of food. The main exports include sugarcane, beef, soybeans, coffee, and orange juice. Brazil is a major world exporter of coarse grain due to its strategic agricultural policy that has contributed to the development of agriculture over the past 30 years. This policy was driven by the need to guarantee food security to the growing population since importing food has become expensive and unsustainable. Agrarian reforms abandoned extensive and intensive methods and pushed for a resource-based concept and sustainable models.

**Russia.** Russia has a mixed economy following privatization of industry and agriculture in the 1990s and is much less dependent on energy import. According to the World Bank (2021), Russia reported negative annual GDP growth rates in the 1990s, with a slight reprieve in 1997 when the rate was 1.4%. Thereafter, only 1998, 2009, 2015 and 2020 were in the negative and these years correspond to global financial, commodity and health crises. Other BRICS countries also experienced a dip in 2009, but none of them landed in the negative territory. However, Brazil was also in the negative territory in 2015 and 2020 (World Bank, 2021). The 1998 currency crisis was a result of a chronic fiscal deficit due to the war in Chechnya, which coincided with external shocks from the 1997 Asian crisis and falling oil prices. While political stability in other BRICS economies attracts huge amounts of FDI, Russia’s case is somewhat different since global investors often want to avoid regions of political uncertainty.

As the largest crude oil exporter in the BRICS bloc, Russia is facing cutbacks in revenue due to depressed oil prices. This can lead to budget cuts, contractionary fiscal policy and massive external borrowing. In 2012, oil and gas accounted for 16% of GDP. Russia has the largest natural gas reserves and the 8th largest oil reserves in the world. Russia’s oil production has been on the rise for 7 years, making Russia the world’s largest oil exporter in 2015. In 2019, Russia produced 11.5 million barrels of oil per day and consumed 3.32 million barrels per day, which means that approximately 70% of oil was exported (BP Statistical Review, 2020). Much like the drop in consumption in Brazil in 2015, Russia’s energy consumption in the same period fell, albeit by a wider margin.

Although Russia dominates the global wheat markets, it recorded, on average, only 5.35% of agricultural value added as a percentage of GDP. This suggests the need to invest in research and development in order to add value to agricultural output and thereby fetch higher prices in the global markets or better yet, use such added value to gain a competitive edge in global markets.

A closer look at Russia’s agricultural potential will show that the country has 9% of the earth’s arable land, which is certainly an inimitable and unique resource that ought to be harnessed to gain a comparative advantage in the global food market. According to Printseva (2021), Russia has 50% of the planet’s black soils, one of the planet’s largest freshwater reserves, and 25% of the global forests which, if developed strategically, could eradicate some of the economic woes.

The risks faced by international investors are rising due to high levels of contagion and interdependence among economies, particularly during economic, financial or commodity crises. Globalization, technological advances and deregulation enhance efficiency in global markets, but their flipside is that they tend to breed contagion. Such contagion can rise to toxic levels that can nullify efforts to attain a diversified portfolio.
in a crisis. Empirical evidence shows that oil and food prices have a profound effect on macroeconomic variables, and particularly those of economic blocs. Brazil and Russia jointly stimulate the world demand and supply of oil and food, hence it is imperative to investigate how these economies respond to price volatility in commodity markets. This study analyses macroeconomic shocks and compares the two economies with respect to high levels of volatility in global oil and food prices. In addition, this research attempts to model the extent to which oil and food price volatilities foster interdependence in order to inform policymakers and global investors.

1. Literature review

There is a plethora of literature covering the issues of oil and food price volatilities (Huang et al., 2005; Cologni & Manera, 2008). There are several schools of thought that seek to explain the effects of world oil and food price volatilities on different economies and economic blocs.

Numerous studies have been conducted to investigate the effect of oil price shocks on macroeconomic variables. One group of scholars explored the theoretical dynamic causal effect of oil on output and inflation (Barro, 1984; Darby, 1982; Burbridge, 1984; Mork, 1989; Hamilton, 1996; Bernanke, 2010). Another group conducted an empirical research on the effect of oil price shocks on a wider range of macroeconomic variables (Hamilton, 2009; Mory, 1993; Cunado & Perez de Garcia, 2003; Lee et al., 2001).

Factors impacting the process of determining global oil prices include geopolitical considerations, market uncertainties, ongoing explorations, growing demand and OPEC decisions (Baffes et al., 2015; Ebrahim et al., 2013; Taghizadeh-Hesary & Yoshino, 2015; Cooper, 2021; Edirington, 2002; Simpson, 2008; Hamilton, 2009). Oil markets have witnessed marked volatility over the past three decades. A dynamic model of rational expectations operates in oil markets where spot prices exceed futures prices when short-term supply is low (Lagi et al., 2011). The forces of supply and demand are often influenced by wars, civil unrest, economic crises, adjustments to trade agreements, and unexpected weather. Since oil production is capital intensive, it is a lot easier to store excess supply for the future than to increase production for immediate consumption. Consequently, this breeds speculation in world oil markets which often fuels price volatility (Lagi et al., 2011; Jiang & Tian, 2005).

Oil often attracts speculators and investors due to its fungibility and ease of storage and transportation compared to other energy commodities. The actions of speculators and investors give a more reliable representation of the future of the global economy. Alquist et al. (2011) argue that investors turn to commodity markets to hedge financial risks and this contributes to rising oil prices due to increased demand.

Several scholars also agree that volatility is a permanent feature of global oil markets since oil exhibits the highest volatility in energy markets (Miklian & Andersen, 2014; Plourde & Watkins, 1998). Furthermore, there is a consensus that oil price volatility has an adverse impact on economic growth and stability, investment, human activity, and
national accounts (Miklian & Andersen, 2014; Ramey & Ramey, 1995; Gylfason, 2001; Papyrakis & Gerlagh, 2004; Hamilton, 1983).

Mork (1989) argues that volatility of oil prices matters more than rising price levels because it tends to exacerbate the asymmetrical responses of economic activity. Several researchers confirm the asymmetrical impact of oil price volatility on macroeconomic variables (Federer, 1996; Kuper & Soest, 2006; Rahman & Serletis, 2012; Sadorsky, 1999; Brown & Yucel, 2002; Bredin et al., 2011).

Some scholars agree that oil price volatility negatively affects economic output in the short run, not the long run (Castillo et al., 2010, Baskaya et al., 2013, Guo & Kliesen, 2005; Salim & Rafiq, 2011; Jo, 2012). Furthermore, scholars also agree that investment as well as consumption also fall in response to higher volatility in the world oil markets (Castillo et al., 2010; Elder & Serletis, 2010; Plante & Traum, 2012) — a scenario that is theoretically attributed to higher unemployment as firms try to cut down on production costs (Guo & Kliesen, 2005; Rafiq et al., 2009).

In-depth studies have been conducted to explore the macroeconomic effects of oil price volatility on various economies (Burbridge, 1984; Mork, 1989; Mork et al., 1994; Lee et al., 2001; Khan & Ahmed, 2011; Hamilton, 2009; Uri, 1996; Jo, 2012; Salim & Rafiq, 2011). Guo & Kliesen (2005) studied the effect of oil price volatility on the US economy from 1984 to 1994 using Granger Causality Tests and found that daily volatility of oil futures was inversely related to future GDP. Yang et al. (2012) assessed the Chinese economy and found that oil price volatility Granger caused movements in GDP growth rate, consumer price level and monetary policy, and that economic growth rates Granger caused the price level.

Hamilton (2009) observes that the dramatic drop in world oil prices in 2008 led to a drop in economic production in the USA, which, in turn, prompted retrenchment of employees in various industries. Household incomes declined drastically, leading to defaults on mortgages and subsequent foreclosures and bank failures as the crises escalated. The rise in oil prices in 2012 pushed the US CPI upward, while depressing factory output. Blanchard & Gali (2007) compared the response of US GDP and CPI to the oil price shocks of the 1970s and 2000s and found that the oil shocks were among a number of shocks of different origins and that oil shocks had lower macroeconomic effects in the 2000s than in the 1970s. Evidence from Norway shows that Norway’s GDP fluctuates depending on oil prices, it fell from €50 billion in 2008 to less than €35 billion in 2009 (Miklian & Andersen, 2014). This cements the theory that oil volatility and GDP have an inverse relationship.

Khan & Ahmed (2011) used the SVAR approach and found that Pakistan’s economy was in stagflation due to supply-side shocks from global oil prices. Amjad et al. (2011) also conclude that the supply shocks increased inflation while economic growth was declining, leading to high unemployment rates and poverty in Pakistan. In a study conducted by Baffes et al. (2015), oil price volatility is linked to volatility in foreign exchange markets as well as equity markets. The authors provided evidence of capital outflows from oil-exporting countries in 2014, leading to sharp depreciation of currencies in Russia, Venezuela, Colombia, Nigeria and Angola due to a sharp decrease in oil prices. Oil price volatility
adversely affects both oil-exporting and oil-importing economies, with the latter being more disadvantaged than the former.

Using ARCH/GARCH, Baffes et al. (2015) found that oil price volatility was higher between 2011 and 2014 than in prior periods. Taghizadeh-Hesary & Yoshino (2015) used the SVAR model to analyze the effects of oil price volatility on two groups: the developed US and Japan versus emerging China. They found that GDP growth rates of the latter were more susceptible to oil price fluctuations than of the former, yet the inflation response of China was found to be milder than that of the US and Japan. China’s low inflation rate was attributed to higher economic growth rates which shift the aggregate supply curve to the right, thereby mitigating a rise in the price level.

According to the Commonwealth Scientific and Industrial Research Organization (CSIRO), there has been a 77% increase in food imports over the past five decades, which indicates that the global village is becoming increasingly interdependent. Over the past decade, grain prices have risen significantly due to unfavourable weather conditions as well as increasing demand for biofuels as governments push for alternative energy sources. Wright (2011) and Gilbert & Morgan (2011) concur that low stock levels amplify grain price volatility. These authors found that the 2007–2008 price hikes were the result of low storage levels after the diversion of large volumes of grains and oilseeds to biofuels production without allowing enough time to build stocks through new high yield varieties. Thus, Gilbert & Morgan (2011) conclude that volatility will remain high in the medium term until productivity increases.

Several causes of rising food prices have been documented by economists. Gilbert (2010) claims that high food prices in the 2000s were driven by rapid economic growth in Asia, while the World Bank attributed the increase in prices to underinvestment in agriculture. Wright (2011) and Mitchell (2008) identify the prolonged Australian droughts of 2006–2007 and poor harvests in Europe in 2007 as contributing factors, while Abbott et al. (2008) conclude that the depreciating US dollar is the key driver of rising food prices.

The unpredictable variability of food prices is attributed to production shocks caused mainly by unfavorable weather and demand shocks derived from incomes and policy changes (Gilbert, 2006; Christiaensen, 2009; Hajkowicz et al., 2012). There is a general consensus that global warming will continue to adversely affect agricultural output in the long run, which means that part of the increase in food price volatility experienced over the past two decades is actually permanent. Gilbert & Morgan (2011) note that episodes of high volatility in food prices are short-lived and often followed by lengthy periods of stability, which implies that the 2008 price spike may not necessarily be a recurring event in the near future. Studies such as Bloch et al. (2007) demonstrate that global food price volatility has a direct effect on consumer price inflation and it often prompts demands for higher wages. However, some scholars argue that this link is getting weaker in developed countries due to advanced derivative markets and crop insurance (Gilbert & Morgan, 2011; Moschini & Hennessy, 2001).

In their study, Ridler & Yandle (1972) conclude that since most commodity prices are quoted in US dollars, the exchange rate variability of the USD will feed into that of world oil and food prices. Furthermore, the variability of the local currency against the USD
The impact of world oil and food price shocks on the interdependence...

will also fuel volatility. Numerous strategies are being adopted by governments to curb imported food price volatility and one of them entails the use of buffer stocks. Miranda & Helmberger (1988) study the effect of government intervention on the US soybean market and find that food programs lead to price stabilization in the long run but also crowd out the private sector. Salant (1983) shows that public stockholding perpetuates speculation, particularly in landlocked countries with limited access to world markets.

Recent studies show that the quest for alternative sources of energy necessitated by rising oil prices has driven major economies, such as the USA, to divert food stocks to biofuel production (Gilbert & Morgan, 2011; Baffes, 2007; Mitchell, 2008). Brazil has an upper hand in this regard as ethanol fuel produced from sugar yields more energy than that derived from corn, the US option. Some researchers agree that oil and food price volatility has an adverse effect on the rate of world economic growth (Headey & Fan, 2008; Abbott et al., 2009; Galesi & Lombardi, 2009). Volatile food prices increase import bills of food-importing countries, which can lead to trade deficits and an unfavourable balance of payments in the long run. Further, rising food prices may increase the demand for money and raise interest rates, which will lead to unfavourable exchange rates. It was against this background that the researchers opted to study the effects of oil and food price volatility on output, inflation, money supply, interest rates, and exchange rates.

2. Materials and methods

This study uses a systematic approach to data collection, analysis, and presentation. The researchers adopted a non-interventionist theoretical approach anchored on time series of observed data on several variables in order to draw conclusions after their thorough analysis. The same research design was adopted by a number of scholars who studied the interdependence among economies using historical time series data (Engle, 1982; Patton, 2006; Silvennoinen & Thorp, 2009). The study covers the period from October 1996 to March 2021, inclusive. Firstly, volatilities of global oil and food prices were measured, then oil and food price shocks for five key macroeconomic variables were computed and analyzed using the Structural Vector Autoregressive Approach (SVAR). After that, the Impulse Response Functions (IRF) were computed for a period of 12 months. In an attempt to completely capture the effects of innovations related to oil and food, the residuals of the SVAR were analyzed using a DCC-GARCH model which allowed to compare the levels of interdependence during volatile and calm periods.

2.1. Autoregressive conditional heteroskedasticity (ARCH/GARCH) models

The dynamic nature of economic time series data has been at the center of academic studies for several decades. Volatility is a phenomenon of wide swings found in time series data (Gujarati, 2004; Brooks, 2008). The ARCH family of models was pioneered by Engle (1982) and this approach involves the calculation of standard deviations of log ratios of time lags. This model attempts to incorporate the heteroscedasticity observed
at different periods in a time series. The ARCH and GARCH models are not aimed at correcting heteroscedasticity but at modelling it and predicting variation for each term (Engle et al., 1990). Bollerslev (1986) develops this idea further by introducing declining weights for older data that are asymptotic to zero. Bollerslev (1986) argues in favor of a model that distinguishes between predictable and unpredictable components but also allows for the variance of an unpredictable component using a generalized autoregressive conditional heteroscedasticity model (GARCH).

According to Engle (2001), the GARCH model has the following form:

\[ h_{t+1} = \omega + \alpha(r_t - m_t)^2 + \beta h_t = \omega + \alpha\varepsilon_t^2 + \beta h_t, \]

where: \( h_t \) is the variance of the residuals of regression, \( r_t = m_t + \varepsilon_t \);
\( \omega, \alpha \) and \( \beta \) are positive constants to be estimated;
the weights are \( (1 - \alpha - \beta, \beta, \alpha) \);
long-run variance is \( \omega \alpha\beta \sqrt{\frac{1}{1 - \alpha - \beta}} \), where \( |\alpha + \beta| < 1 \).

When the volatility graphs were produced, periods of high volatility were identified for comparison with correlation coefficients in the DCC-GARCH results.

2.2. Structural vector autoregressive models and impulse response functions

The SVAR approach requires that the data in the time series be stationary at the same level in order to avoid spurious results. The Augmented Dickey-Fuller (ADF) test for stationarity was developed by Dickey and Fuller in 1979. The ADF is a unit root test with a null hypothesis that states that a series has a unit root, which means that it is non-stationary.

The nature of this study required that we selected the most appropriate lag length to obtain the best model. The Akaike Information Criterion (AIC) compares different econometric models on the basis of the information lost when using a particular model. This approach was developed by H. Akaike in 1974 (Akaike, 1974). The Bayesian information criterion (BIC) imposes stricter penalties to avoid overfitting and is more preferred by researchers, especially in studies with large samples (Koehler & Murphree, 1988). The Hannan-Quinn information criterion (HQIC) imposes a penalty for adding more regressors to the model in an attempt to minimize the value of the residual sum of squares (Hannan & Quinn, 1979).

Four SVAR models were developed, two for each economy, one with oil as the exogenous variable and another with food. Vector autoregressive (VAR) models are used to model simultaneous equations whereby each endogenous variable is explained by its lag values, as well as lagged values of other endogenous variables under study (Gujarati, 2004). One of the major drawbacks of VAR is that it disregards information about specific drivers of each variable assuming symmetrical effects in a structural sense. As such, the Structural VAR (SVAR) was developed by Professor Sims in 1980 to allow for each variable to be independently affected by the exogenous variable as is often the case in economics. SVAR allows the researcher to identify unexpected structural effects of one variable on
other variables and determine which variables are exogenous and which are endogenous, based on economic theory (Chuku et al., 2011; Khan & Ahmed, 2011; Leeper et al., 1996). Further, SVAR caters for short-run effects of variables on each other, rather than immediate effects as implied by VAR. As such, this model is preferred and often followed by the impulse response function (IRF) that models the transmission of shocks in the short run (Khan & Ahmed, 2011; Kim, 2005). The model assumes that structural shocks are not correlated, which is supported by economic theory. If an error term (impulse or shock) changes by 1 standard deviation, it will trigger a change in the exogenous variable of this particular equation, but since there are endogenous variables in this regression equation, they will also change. The impulse response functions capture the snowball effect of the error term on all variables in the given equation (Gujarati, 2004). The generalized impulse response function (IRF) fully accounts for the historical patterns of correlations observed amongst different shocks (Koop et al., 1996).

The key stage in the SVAR model is identification. We needed to identify matrix A in the SVAR equation below:

\[ AX_t = A_1 X_{t-1} + A_2 X_{t-2} + \ldots + A_p X_{t-p} + \epsilon_t, \] (2)

where: \( X_t \) is a \((n \times 1)\) vector of endogenous variables \([X_t = (o_t^*, f^*_t, y_t, p_t, m_t, i_t, e_t)]\) that is oil (or food — \(fo^*_t\)) price, federal funds rate, output, consumer price inflation, money supply, short-term interest rate, and real effective exchange rates, respectively;
\( A \) is an invertible \((n \times n)\) matrix of coefficients of endogenous variables;
\( A_i \)'s are \((n \times n)\) matrices that show the dynamic relationships among all the \(k\) variables;
\( \epsilon_t \) is an \((n \times 1)\) vector of structural error terms;
\( p \) is the number of time lags.

Kim and Roubini (1999) introduce a robust model that includes the effect of the US Federal Funds Rate on the exchange rates of the G6 economies. However, Brischetto and Voss (1999) adopt the model of Cushman and Zha (1997) which captures the effect of federal rates on domestic interest rates, arguing that it presents more realistic results since federal funds rates are an indicator of oil inflation as oil prices are given in US dollars.

The SVAR model for global oil prices is structured as follows (Brischetto & Voss, 1999):

\[
A_0 x_t = \begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 \\
-a_{21}^0 & 1 & 0 & 0 & 0 & 0 & 0 \\
-a_{31}^0 & 0 & 1 & 0 & 0 & 0 & 0 \\
-a_{41}^0 & 0 & -a_{43}^0 & 1 & 0 & 0 & 0 \\
0 & -a_{53}^0 & -a_{54}^0 & 1 & -a_{56}^0 & 0 & 0 \\
-a_{61}^0 & -a_{62}^0 & 0 & 0 & -a_{65}^0 & 1 & -a_{67}^0 \\
-a_{71}^0 & -a_{72}^0 & -a_{73}^0 & -a_{74}^0 & -a_{75}^0 & -a_{76}^0 & 1 \\
\end{pmatrix}
\begin{pmatrix}
o_t^* \\
f^*_t \\
y_t \\
p_t \\
m_t \\
i_t \\
\epsilon_t \\
\end{pmatrix} \] (3)
The Lagrange Multiplier (LM) test for ARCH was developed by Engle in 1982 and is used to determine the validity of SVAR restrictions since the model was over-identified. The null hypothesis states that the error terms of the SVAR models are homoscedastic and the null hypothesis is rejected when the $p$-value exceeds 5%.

Further, the Jarque-Bera test for normality was developed by C. Jarque and A. K. Bera in 1980. This test was employed to test the residuals for normality to authenticate the SVAR model. An Autoregressive (AR) model that captures the appropriate lag length is expected to capture all the variability that is explained by its lags, so that the error terms are independent. The test measures the skewness and kurtosis with the null hypothesis that a variable follows the normal distribution.

### 2.3. Dynamic Conditional Correlation (DCC-GARCH)

Various scientists have developed several approaches to multivariate GARCH models for calculating the correlation matrix. Bollerslev (1990) developed a constant conditional correlation estimator in which the conditional correlation matrix $R$ was constant. Engle (2002) modified Bollerslev’s work and proposed a dynamic conditional correlation (DCC) model in which $R$ varied with time, which is often the case in economic and financial data series. The Dynamic Conditional Correlation (DCC-GARCH) model was used by several scholars to assess contagion (Chao & Parhizgani, 2008; Bonga-Bonga, 2015). The DCC-GARCH model incorporates univariate GARCH models with parsimonious parametric models in order to model time-varying correlations. This model is often preferred because it is nonlinear in nature (Engle, 2002). By avoiding the complexity of multivariate GARCH models, the DCC-GARCH directly parameterizes conditional correlations, which simplifies computation since the number of parameters does not depend on the number of time series to be correlated. This advantage allows for large correlation matrices to be studied and helps to model the asymmetric effects of exogenous variables on several endogenous ones. Engle and Sheppard (2001) specified the DCC-GARCH model as follows:

$$ r_t \bigg| \xi_{t-1} \sim N(0, D_t R_t D_t), $$  

where:

$$ D_t = \text{diag}\{w_t\} + \text{diag}\{k_t\} \circ r_{t-1} r_{t-1}' + \text{diag}\{\lambda_t\} \circ D_{t-1}; $$

$$ \xi_t = D_t^{-1} r_t; $$

$$ R_t = \text{diag}\{Q_t\}^{-1} Q_t \text{diag}\{Q_t\}^{-1}; $$

where $R_t$ is the correlation matrix containing the conditional correlations; the $k \times k$ symmetric positive definite matrix $Q_t$ is given by:

$$ Q_t = (1 - \theta_1 - \theta_2) \frac{\bar{Q}}{2} + \theta_1 \xi_{t-1} \xi_{t-1}' + \theta_2 Q_{t-1}; $$

where $\theta_1$ and $\theta_2$ are non-negative scalar parameters that capture the effects of previous shocks and previous dynamic conditional correlation, respectively (Chang et al., 2011).

According to Bonga-Bonga (2015), the residuals of the SVAR model were the input of the DCC-GARCH model. The output graphs of the DCC-GARCH were compared to the volatility graphs of global oil and food prices in order to identify the behavior of correlations during periods of high volatility and volatility clustering.
3. Data sources

All data was extracted from the Federal Reserve Bank of St. Louis and cited accordingly. Monthly time series data from October 1996 to March 2021 were used. The variables in this study can be grouped into 2 categories, namely international and domestic. The international variables are world oil and food prices. The domestic variables are industrial output, inflation rate, money supply, nominal interest rates, and real effective exchange rates.

World oil prices \( (o_t) \) were proxied by the West Texas Intermediate (WTI) monthly spot price in US dollars. The WTI is the most preferred source because it represents trade in the advanced and efficient US oil markets. World food prices \( (f_{ot}) \) were proxied by the Global Price of Food Index, the average monthly price in nominal USD with 2016 as the base year. Production Total Industry (PTI) was measured by the total industry production \( (y_t) \) in each country, which is indicative of the productive activities of economic agents. Inflation \( (p_t) \) was proxied by CPI which is expressed as an index of base year 2010 for both countries. Inflation is important for this study because an oil shock often manifests in the growth of consumer prices, hence the need to model the impact of oil shocks on each economy’s level of inflation. Whenever monetary authorities anticipate an oil shock, they tend to adjust the level of money supply \( (m_t) \) in the economy in order to safeguard the local economy from the shock. These interventionist activities often involve the use of short-term interest rates and money supply to achieve the desired goal. Therefore, an immediate 24-hour call money (interbank) rate was used to represent short-term interest rates \( (i_t) \). Annualized rates were used since they are always expressed as a percentage. The US federal funds rate was represented by \( (f_{it}) \). The reciprocal of the exchange rates \( (e_t) \) of each of the BRICS currencies against the USD was taken to represent the real effective exchange rates. All data were converted into natural logarithms, except interest rates and the federal funds rate, in order to standardize the unit of measurement.

4. Results

This section presents the results in chronological order, starting with the ARCH/GARCH models followed by the SVAR and IRF models and ending with the DCC-GARCH results. The ADF test results showed that all the time series used had a unit root meaning that they were not stationary. Upon first differencing, the data was found to be stationary, hence it was analyzed as such.

3.1. ARCH/GARCH volatility models

Volatility of world oil prices. From 1996 to 2007, most of the volatility was explained by geopolitical crises in the Middle East and the failure to increase production to match the growing global demand. The three periods of marked volatility are the global financial crisis of 2008–2009, the commodity crisis of 2014, and the onset of the Covid-19 pandemic in...
early 2020. Figure 1 models the volatility of world oil prices from October 1996 to March 2021. The equation is given by:

\[ h_{t+1} = 0.005 + 0.431 h_{t} \varepsilon_{t}^{2} + 0.000 h_{t}, \]  \hspace{1cm} (5)

which means that only the ARCH term was found to be significant.

\[ \text{Figure 1. Volatility of world oil prices} \]

\textbf{Volatility of world food prices.} As seen in Figure 2, world food prices exhibited relatively low volatility prior to the global financial crisis of 2008—2009. There is one prolonged period of high volatility — from 1\textsuperscript{st} quarter of 2008 to 2\textsuperscript{nd} quarter of 2010. The equation is given by:

\[ h_{t+1} = 0.0002 + 0.089 h_{t} \varepsilon_{t}^{2} + 0.64 h_{t}. \]  \hspace{1cm} (6)

However, only the GARCH term with a \textit{p-value} below 0.05 is significant.

\[ \text{Figure 2. Volatility of world food prices} \]
Dynamic conditional correlations of economic time series were analyzed based on the periods of excessive volatility in order to assess whether oil and food price volatility influences the levels of interdependence of the two economies.

3.2. SVAR and IRF models

The structural vector autoregressive model is used to isolate contemporaneous relations between two or more variables. According to the results of the Akaike information criterion (AIC), Bayesian information criterion (BIC) and Hannan-Quinn information criterion (HQIC), the Brazilian models were estimated with one lag, while the Russian ones were estimated using four lags. Two separate matrices were developed for each country to measure the impact of oil and food shocks, respectively, in order to isolate the direct impact of each exogenous variable. The p-values of the (LM) ARCH and the Jacque-Bera normality tests were below 5% for all SVARs, which indicates that the residuals of the SVARs are homoscedastic and follow a normal distribution, respectively.

Brazil’s SVAR and IRF oil model. The structural coefficients for the Brazilian oil model are given below.

<table>
<thead>
<tr>
<th>$o_t$</th>
<th>$f_t$</th>
<th>$y_t$</th>
<th>$p_t$</th>
<th>$m_t$</th>
<th>$i_t$</th>
<th>$e_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>-2.665 (0.220)</td>
<td>1</td>
<td>0</td>
<td>-0.016 (0.008)</td>
<td>1</td>
<td>-76.47</td>
<td></td>
</tr>
<tr>
<td>-0.198 (0.029)</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>-40.92 (305.6)</td>
<td>2.53 (3020)</td>
<td>1</td>
</tr>
<tr>
<td>0.004 (0.002)</td>
<td>0</td>
<td>-0.016 (0.008)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>-387.5</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>-40.92 (305.6)</td>
<td>2.53 (3020)</td>
<td>1</td>
<td>-76.47</td>
<td></td>
</tr>
<tr>
<td>0.088 (25.226)</td>
<td>0.217 (19.594)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-387.5</td>
<td>1</td>
</tr>
<tr>
<td>-0.049 (0.151)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: LR Overidentification Test $\chi^2 (4)$ 785 (2e-16).

Source: calculated by the authors.

The results presented in Table 1 show that oil has a negative impact on output, which differs from the findings of Brischetto and Voss (1999) who used the same...
model for Australia, a net importer of oil. However, the results are similar to the findings of Kim and Roubini (1999) for the United Kingdom and France. The impact of oil on inflation and interest rates is positive for Canada, as found by Kim and Roubini (1999), Brischetto and Voss (1999) in the Australian model, and Khan and Ahmed (2011) in the Pakistani model. The effect of oil on exchange rates is negative in line with the finding of Kim and Roubini (1999) in their German, Japanese and French models.

![Impulse response functions for the Brazilian oil model](image)

Source: calculated by the authors.

**Figure 3.** Impulse response functions for the Brazilian oil model

The orthogonal impulse function for the Brazilian model (Figure 3) shows short-lived effects because the model was estimated with only one lag. In response to oil shocks, output rises, prices also increase, money supply falls, interest rates move upward slightly. However, they all revert back to the pre-shock levels within 6 months.

*Brazil’s SVAR and IRF food model.* The Brazilian SVAR food model was estimated as follows.
Table 2. $A_{x_t}$. Matrix Food — Brazil

<table>
<thead>
<tr>
<th>$f_{0_t}$</th>
<th>$f_{1_t}$</th>
<th>$y_t$</th>
<th>$p_t$</th>
<th>$m_t$</th>
<th>$i_t$</th>
<th>$e_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.826</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.266)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.113</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.050)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.004</td>
<td>0</td>
<td>-0.014</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.006)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>-11.43</td>
<td>0.873</td>
<td>1</td>
<td>-59.45</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(150.1)</td>
<td>(1865.9)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.935</td>
<td>15.48</td>
<td>0</td>
<td>0</td>
<td>87.33</td>
<td>1</td>
<td>2087</td>
</tr>
<tr>
<td>(207.7)</td>
<td>(43.54)</td>
<td>0</td>
<td>0</td>
<td>(112.2)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>71.66</td>
<td>3.028</td>
<td>-25.17</td>
<td>12.00</td>
<td>-257.43</td>
<td>-0.413</td>
<td>1</td>
</tr>
<tr>
<td>(6.328)</td>
<td>(29.24)</td>
<td>(207.8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: LR Overidentification Test $\chi^2 (4) 15 (0.005)$.

Source: calculated by the authors.

Figure 4. Impulse response functions for the Brazilian food model
Figure 4 shows the orthogonal impulse response of output to world food prices. It is evident that innovations in the field of food are immediately felt with a rise in output and inflation, a fall in money supply and interest rates, and an appreciation of the local currency against the USD.

Russia's SVAR and IRF oil model. Contemporaneous structural coefficients were calculated as follows.

**Table 3. $A_{x_t}$ Matrix Oil — Russia**

<table>
<thead>
<tr>
<th></th>
<th>$o_t^*$</th>
<th>$f_i^*$</th>
<th>$y_t$</th>
<th>$p_t$</th>
<th>$m_t$</th>
<th>$i_t$</th>
<th>$e_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>−0.434</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.077)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>−0.014</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(0.011)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.003</td>
<td>0</td>
<td>0.016</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(0.004)</td>
<td></td>
<td>(0.021)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>−0.389</td>
<td>0.263</td>
<td>1</td>
<td>0.000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.123)</td>
<td>(0.371)</td>
<td></td>
<td>(0.001)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>−1.329</td>
<td>−0.914</td>
<td>0</td>
<td>0</td>
<td>−3.825</td>
<td>1</td>
<td>−60.51</td>
<td>1</td>
</tr>
<tr>
<td>(10.47)</td>
<td>(3.820)</td>
<td></td>
<td></td>
<td>(25.28)</td>
<td></td>
<td>(67.33)</td>
<td></td>
</tr>
<tr>
<td>0.156</td>
<td>−0.004</td>
<td>0.110</td>
<td>−2.108</td>
<td>0.009</td>
<td>0.001</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>(0.024)</td>
<td>(0.016)</td>
<td>(0.110)</td>
<td>(0.401)</td>
<td></td>
<td>(0.060)</td>
<td>(0.001)</td>
<td></td>
</tr>
</tbody>
</table>

*Note:* LR Overidentification Test $\chi^2$ (4) 46 (2e-09).

*Source:* calculated by the authors.

As in the Brazilian model, Table 3 shows that oil has a negative impact on output, which contradicts the findings of Javid and Munir (2010) who found a positive coefficient. It also shows a positive effect on prices, as in the work by Kim and Roubini (1999) who reported about a positive effect of oil price innovations on the Canadian Consumer Price Index. Oil shocks have a positive effect on exchange rates, which differs from the results of Javid and Munir (2010) for Pakistan. Oil has a negative effect on interest rates — a finding which contradicts Javid and Munir (2010) and Brischetto and Voss (1999). However, Kim and Roubini (1999) found a negative effect for Germany, Japan and France.

The orthogonal impulse response to world oil shocks tends to last longer in Russia than in Brazil, probably, because up to four lags were necessary to estimate an efficient SVAR model. The graphs in Figure 5 indicate that macroeconomic variables follow a path of marked volatility as they revert to pre-shock levels, hence it takes longer for them to settle. Output, money supply and interest rates are rising in response to innovations in the oil market, while inflation is declining and the Ruble is appreciating.
The impact of world oil and food price shocks on the interdependence...

Source: calculated by the authors.

**Figure 5.** Impulse response functions for the Russian oil model

Russia’s SVAR and IRF food model. The Russian SVAR food model was computed as follows.

**Table 4.** $A_{oo}$ Matrix Food — Russia

<table>
<thead>
<tr>
<th>$f_0^o$</th>
<th>$f_1^o$</th>
<th>$y_t$</th>
<th>$p_t$</th>
<th>$m_t$</th>
<th>$i_t$</th>
<th>$e_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.802</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.270)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.218</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.038)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.054</td>
<td>0</td>
<td>-0.024</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.013)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>-0.266</td>
<td>-0.254</td>
<td>1</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>(0.117)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4. Continued

<table>
<thead>
<tr>
<th>$f_{i_t}$</th>
<th>$f_{i_t}'$</th>
<th>$y_t$</th>
<th>$p_t$</th>
<th>$m_t$</th>
<th>$i_t$</th>
<th>$e_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.093</td>
<td>0.095</td>
<td>0</td>
<td>0</td>
<td>-7.380</td>
<td>1</td>
<td>-32.47</td>
</tr>
<tr>
<td>(170.35)</td>
<td>(36.78)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.728</td>
<td>0.051</td>
<td>0.332</td>
<td>-1.663</td>
<td>0.222</td>
<td>0.002</td>
<td>1</td>
</tr>
<tr>
<td>(0.109)</td>
<td>(0.021)</td>
<td>(0.152)</td>
<td>(0.440)</td>
<td>(0.077)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: LR Overidentification Test $\chi^2 (4) = 1501 (2e-16)$.

*Source: calculated by the authors.*

Table 4 presents the food matrix for Russia. In contrast to the findings of Khan and Ahmed (2011), food shocks have a positive effect on inflation mainly because Russia is a major exporter of food and Pakistan is a net importer. World food prices seem to have a negative effect on output, driving industrial production down, since agriculture accounts for a significant portion of economic activity in Russia. Further, food prices have a positive effect on interest rates and exchange rates for the same reason.

*Source: calculated by the authors.*

**Figure 6.** Impulse response functions for the Russian food model
As can be seen from Figure 6, impulse responses exhibit rugged movements, sometimes crossing from negative to positive territory after food price innovations. Initially, output, inflation and interest rates respond by rising, while the foreign exchange appreciates against the USD. Thereafter, all variables experience alternating periods of ups and downs before arriving at the pre-shock levels. Inflation, money supply and the foreign exchange rate tend to take longer to return to the pre-shock readings.

### 3.3. DCC-GARCH models

DCC-GARCH oil model. DCC-GARCH computations employed for measuring the spillover effects from Russia to Brazil (and vice versa) using the residuals of the SVAR oil models yielded the following p-values.

<table>
<thead>
<tr>
<th></th>
<th>Output (y)</th>
<th>Inflation (p)</th>
<th>Money supply (m)</th>
<th>Interest rates (i)</th>
<th>Exchange rate (e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$dcca1$ (short-run)</td>
<td>0.467</td>
<td>0.998</td>
<td>0.007</td>
<td>0.999</td>
<td>0.004</td>
</tr>
<tr>
<td>$dccb1$ (long-run)</td>
<td>0.040</td>
<td>0.000</td>
<td>0.000</td>
<td>0.001</td>
<td>0.000</td>
</tr>
</tbody>
</table>

*Source: calculated by the authors.*

As shown in Table 5, only long-term spillover effects are significant for output, inflation and interest rates. Money supply and exchange rate are characterized by both short-term and long-term spillover effects, which means there is a higher risk of contagion in an oil or food crisis. The plot of dynamic correlations for output shows that the highest possible positive correlation is 0.3, which is a fairly low correlation. However, correlations for money supply and exchange rates are strong enough to perpetuate contagion in a crisis.

The peaks of output are far greater than those of oil volatility, and in most cases when they coincide, correlations seem to over-compensate for the oil volatility, which indicates that there are other factors that influence the interdependence. In early 2020, output recorded the highest dynamic correlation coefficient during the onset of the Covid-19 pandemic when oil price volatility also shot up. However, in 2018 and during the commodity crisis of 2014–2015, the correlations were negative. During the global financial crisis of 2008–2009, the second highest positive correlation was observed, albeit below 0.3. The third highest positive correlation was reported in mid-2001, but the volatility of oil was mild. The BRIC was formed in 2009, but there is no significant shift in time-varying correlations from that time to date.

The results in Figure 7 show that correlations range between 0.15 and 0.16, which can be easily diversified by a prudent investor. Similarly, the time-varying correlations for interest rates are negligible ranging from 0.02 to 0.03. There are three significant peaks in the positive region, namely early 2001, late 2007, and early 2020. One significant dip occurred in early 2005 and amounted to -0.2.
The general pattern of the graph of conditional correlations of money supply to oil mimics that of raw data on money supply. For more than 90% of the time under study, the coefficients ranged from 0.5 to 0.85, indicating fairly strong positive correlation. The highest recorded correlation was in 2015. There was a drop in the period from the end of 1998 to the middle of 2000, as per the results in Figure 8.

Correlations dropped to -0.25 in 2002, and this was the only episode of an inverse relationship, as shown in Figure 9. For about 60% of the time under study, the time-varying coefficients ranged from 0.2 to 0.7, which indicates a moderate direct relationship.
The impact of world oil and food price shocks on the interdependence...

Figure 9. Time-varying correlations for oil — exchange rate model

DCC-GARCH food model. Table 6 contains the p-values of the food model.

Table 6. DCC-GARCH food model

<table>
<thead>
<tr>
<th></th>
<th>Output (y)</th>
<th>Inflation (p)</th>
<th>Money supply (m)</th>
<th>Interest rates (i)</th>
<th>Exchange rate (e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( dcca1 ) (short-run)</td>
<td>0.033</td>
<td>0.998</td>
<td>0.010</td>
<td>0.999</td>
<td>0.000</td>
</tr>
<tr>
<td>( dccb1 ) (long-run)</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Source: calculated by the authors.

According to Table 6, only long-run spillover effects are significant for all macro-economic variables. Inflation and interest rates do not exhibit short-term spillover effects, as in the oil model. However, output has significant short-term transmissions here, unlike the oil model. Figure 9 shows dynamic correlations for output with a cap of 0.15 and six significant peaks.

Correlations for interest rates are below zero and within the -0.008 and -0.007 range, which indicates that there is no interdependence between the two economies. Coefficients from inflation lie between 0.13 and 0.14, thereby presenting a low risk of interdependence, as shown in Figure 10.

Confirming the oil model, Figure 11 shows that correlations for foreign exchange are positive in the range from 0.6 to 0.85 for 80% of the time under study. There are slight upward peaks in 2007–2008 and 2015 and a pronounced decline from the end of 1998 to mid-1999 within the 0.28-0.4 range.

As presented in Figure 12, dynamic correlations were in the positive region with two major peaks in 2008, 2012 and 2020. However, there was an inverse relationship between mid-2002 and the end of 2003.
Figure 10. Time-varying correlations for food — output model

Source: calculated by the authors.

Figure 11. Time-varying correlations for food — money supply model

Source: calculated by the authors.

Figure 12. Time-varying correlations for food — exchange rate model

Source: calculated by the authors.
4. Interpretation and discussion of the results

The study uses time-varying correlations in the quest to capture the effect of oil and food price shocks on the interdependence of Brazil and Russia. The GARCH models for oil and food were compared to the DCC-GARCH models to reveal the extent to which the correlations of the macroeconomic variables responded during periods of high volatility.

4.1. Reaction to oil price shocks

It was shown that the periods of highest volatility in world oil prices were the 2008–2009 global financial crisis, the commodity crisis of 2014, and the advent of the Covid-19 pandemic in early 2020 (see Figure 1). Dynamic correlations of the output model concurred with oil volatility only in the third episode. Although higher positive correlations were observed in 2008–2009, the coefficients were much lower than those recorded only in early 2008. Furthermore, the correlations realized in 2014 were actually lower than those in mid-2001. Since Brazil and Russia are major producers of oil, it was expected that the correlations for output would mimic the volatility of oil prices. Leduc and Sill (2004) corroborated this result for Russia, crediting it to the policy of price stability.

Inflation and interest rates yielded almost constant correlations, which did not suggest that there was a relationship between these variables and oil-related innovations. The case for inflation is explained by the price stability mechanisms employed by the Russian central bank. Kilic and Cankaya (2020) found contradictory results in relation to the Russian interest rates, reporting a significant interest rate innovation from oil price shocks. However, Ben Lalouna and Pearlman (2018) found that Brazilian interest rates were robust, not responding to oil innovations, and attributed this phenomenon to relatively high interest rates since 1980.

Correlations for the money supply model do not seem to have any relationship with the oil volatility model. Since the money supply is controlled by the monetary authorities of both countries, this is mostly explained by local rather than international factors. It is for this reason that most scholars preclude the money supply from their studies (Kilic & Cankaya, 2020; Ben Lalouna & Pearlman, 2018).

As in the output model, dynamic correlation coefficients for exchange rates declined rather than increased in 2014 during the commodity crisis. This is a favorable observation from an investment management perspective because it proves that a commodity crisis does not amplify their interdependence. Likewise, correlations were relatively lower than expected during the global financial crisis of 2008–2009. In contrast to the output model, correlations in the exchange rate model rose to their highest peak in early 2020, as did oil volatility. The second highest peak was recorded in the period from mid-2011 to early 2012, which coincided with a moderately tranquil period for oil prices. The Russian central bank has adopted an exchange rate stability regime allowing for intermittent floating of the Ruble in exceptional cases (The Central Bank of the Russian Federation, 2021). This
directly impacts the behavior of time-varying correlations and renders them unlikely to track the world oil price volatility.

If the three crises that affected oil price volatility could be compared in terms of financial severity, the Covid-19 pandemic would be the most serious. The results show that oil innovations compounded positive correlations during that time and would probably foster contagion under similarly stressful conditions.

4.2. DCC-GARCH – Food

Dynamic conditional correlations were computed for paired economic indicators for comparison with the food price volatilities (see Figure 2). There was significant volatility in world food prices during the 2008–2009 global financial crises. However, relative tranquility was observed throughout the rest of the time under study, even during the Covid-19 pandemic. Output correlations rose sharply in early 2020 in response to the pandemic, like in the oil model. The second highest positive correlation was observed in 2001. Surprisingly, low correlations in 2008–2009 are sandwiched by periods of higher correlations. This puzzle is analogous to the one in the oil model and represents a positive development for international investors.

With seemingly stable correlation coefficients throughout the period of study, inflation and interest rate variables did not respond to international food price shocks. The observed near-zero correlations point to no association between the interdependence of Brazil and Russia and food innovations.

Interestingly, the money supply returned a similar pattern of time-varying correlation coefficients to the oil model. This behavior could be attributed to the level of control imposed by the monetary authorities. Correlations plunged slightly during 2008–2009, yet their fall cannot be directly linked to international food prices.

In the exchange rate model, the highest peaks of correlations were noted in early 2020 and 2012 when food prices were relatively stable. In contrast, there was a dramatic fall in the coefficients in 2008 when food prices were experiencing the highest volatility.

The concept of matching food price volatility with dynamic correlations in order to identify episodes of convergence is innovative. While the SVAR food output was comparable to other studies, the results of the DCC-GARCH could not be compared with other empirical literature.

Conclusions

Overall, more peaks of time-varying correlations in the oil model may be attributed to oil price volatility rather than to food price volatility in the food model. However, the results show that Brazil and Russia have long-run spillover effects on all macroeconomic variables in response to both oil and food price shocks. This finding is comparable to that of Li and Guo (2021), who found that oil price volatilities were a statistically significant determinant of spillover effects among the BRICS economies in general. Furthermore, the money
supply and exchange rate variables exhibited short-run effects with high positive dynamic correlations. The interdependence of output and exchange rate variables defied the global financial crisis of 2008–2009 and the commodity crisis of 2014 but rose significantly during the Covid-19 health crisis. This mollifies investors’ concerns during financial and commodity crises but leaves them exposed to other global crises of greater reach and severity. Similarly, food price volatility coincided with a drop in correlations for output and exchange rates variables. The money supply exhibited a unique pattern that could not be directly linked to oil and food price volatility. Interest rates and inflation had constant dynamic correlations that did not respond to innovations related to oil or food. A prudent investor will strive to attain a diversified portfolio of the BRICS countries and some other blocs or large economies that are major importers of oil and food produce.

Of all the variables under study, the money supply produced strong positive correlations before and after the formation of the BRICS. Further studies could investigate this phenomenon because it influences spillover effects both in the short run and more so in the long run. The fact that the DCC-GARCH results showed more peaks than the oil and food price volatility graphs suggests that there are stronger explanatory variables that need to be studied. For example, studies could seek to unearth what happened in 2001–2002, 2011–2012 and 2017–2018 that led to spikes in positive dynamic correlations. Once the appropriate variables are identified, causality studies could also be explored. Such studies should pay attention to regime changes, preferably using spectral causality, in order to estimate the dynamic aspects of causality over time.

References


Organization for Economic Co-operation and Development. (2021, August 26). M1 for Brazil. https://fred.stlouisfed.org/series/MANMM101BRM189N


Analysis of the BRICS countries’ pathways towards a low-carbon environment

Agyemang Kwasi Sampene,*
School of Management, Jiangsu University (China)

Cai Li,
School of Management, Jiangsu University (China)

Fredrick Oteng Agyeman,
School of Management, Jiangsu University (China)

Robert Brenya,
Agricultural Economics and Management, Nanjing Agricultural University (China)


Abstract

Global climate change has emerged as humanity’s greatest challenge, affecting both the natural security of the earth and the long-term growth of human society. Protecting the environment and fostering long-term growth while reducing carbon emissions has become a global concern. The BRICS countries (Brazil, Russia, India, China, and South Africa) are participating in the fight against climate change through the promotion of low-carbon environment (LCE). In this study, we use content analysis to discuss some of the policies, plans, and programs outlined by the various governments in the BRICS that can help them implement an LCE. The study indicates that currently Brazil, Russia, India, China, and South Africa are rated as “insufficient,” “critically insufficient,” “compatible,” “incompatible,” and “highly insufficient” respectively in their commitment to nationally determined contributions (NDC) to the Paris Agreement. The paper recommends that the BRICS countries achieve an LCE through expanding low-carbon investments and financing, focusing on taxation that goes beyond energy, investing in low-carbon cities, adapting to a circular economy and low-carbon technologies, expanding electricity markets, and promoting climate-friendly international trade among the BRICS countries.

* E-mail of the corresponding author: akwasiagyemang91@gmail.com
Introduction

Low-carbon environment (LCE) implementation has become the subject of controversy among governments, scientists, policymakers, and the general public due to the obstacles associated with climate change (CC) and global warming. Economists have tried to assess the socio-economic performance of various countries through the lens of social and environmental welfare, taking into account the environmental and social costs of economic growth (Sheikh, 2021). The primary purpose of an LCE is to reduce global greenhouse gas (GHG) emissions and mitigate the effects of CC (Yang et al., 2019). According to a recent report by the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), global temperatures, GHG emissions, and other factors are increasing exponentially to stages that will have a devastating impact on society (Kirton, 2020). The United Nations report on climate indicates that rising sea levels, permanent changes in ocean currents, the hydrological cycle, vulnerable ecosystems, and more extreme weather events are among the many environmental issues posed by rising emissions (United Nations, 2020). A slew of environmental problems has escalated in the 21st century. Governments worldwide are looking for policies, rules, and ways to reduce the negative impact of socio-economic activities on the environment (Su & Pan, 2019).

Due to the need to protect the environment and foster long-term growth, reducing carbon emissions has become a global concern. During the 1997 Kyoto Protocol, the United Nations Framework Convention on Climate Change (UNFCCC) declared that signatory countries must reduce their GHG emissions by an average of 5% below their 1990 baseline between 2008 and 2012 (Lin et al., 2019). As a result of the UNFCCC Protocol, governments worldwide have implemented regulations to achieve this objective. Although the BRICS countries (Brazil, Russia, India, China, and South Africa) have signed the UNFCCC Kyoto Protocol to reduce emissions, there are still concerns about environmental issues in light of the recent economic boom in these countries (Zakarya et al., 2015). The current agreement on CC is the goal of the Paris Agreement for countries achieving warming below 2°C. The Paris Agreement and the 2030 Agenda for Sustainable Development represent a blueprint for an LCE, as well as climate change (CC) resilient and sustainable future for all countries that needs to be implemented as soon as possible (UNFCCC, 2018).

Over the past 60 years, the BRICS economies have consistently demonstrated high rates of economic development. It is estimated that by 2025, the BRICS economies will account for 50% of the global economy (Liu et al., 2020; Wilson & Purushothaman, 2003). CC has become a fundamental challenge that the BRICS nations and the rest
of the world are facing since 2020 (Kirton, 2020). The BRICS countries differ from each other in terms of cultural background, language, and economic structure. However, these countries have one thing in common: their economic development has exceeded that of the world’s major industrialized nations. The BRICS countries continued to outperform the rest of the globe even after the global financial crisis began in 2007. While emerging economies on average decreased by 6% in 2009, Brazil remained stable, India expanded by 5.9%, and China grew by 8.1%; the group’s worst performer was Russia, which shrank by 7% (Zakarya et al., 2015).

The BRICS countries’ contribution to global economic growth and development should not be underestimated. The financial assistance of these countries stems from the role that entrepreneurs and companies play in such industries as construction, manufacturing, mining, and others. The gross domestic product (GDP) per capita of the BRICS countries is shown in Figure 1. These figures indicate that the BRICS countries’ GDP per capita has increased from $21,240 in 1960 to more than $20 trillion in 2020 (Liu et al., 2020). Specifically, in 2018, nominal growth of GDP in the BRICS countries accounted for 23% of global output (Liu et al., 2020).

![Graph showing GDP per capita of BRICS countries from 1960 to 2020](source: World Bank Data, 2021).

**Figure 1.** Dynamics of GDP of the BRICS countries per capita from 1960 to 2020

Concerns were expressed about the BRICS countries’ social and environmental resilience. For these countries, bridging the economic and ecological gap and minimizing CC is critical for international sustainable development (Dong et al., 2017; Wang et al., 2016). Deterioration of the environment makes us aware of the consequent excessive CO₂ emissions, which contribute considerably to the GHG effect on global economic development (Dong et al., 2017). The BRICS nations had a significant impact on recent international economic growth, as well as on the environment and natural resources in recent decades (Tian et al., 2020). Figure 2 shows trends in CO₂ emissions per capita...
in the BRICS countries from 1960 to 2019. The figures shows an increase in CO$_2$ emission due to the growth of economic development of the BRICS countries.

![CO$_2$ emissions per capita in the BRICS countries from 1960 to 2019](image)


**Figure 2.** CO$_2$ emissions per capita in the BRICS countries from 1960 to 2019

Economists examined the socio-economic performance of various countries through the lens of social and environmental welfare, considering the social and ecological consequences of economic expansion (Sheikh, 2021). Recently, most countries have switched their attention to environmental protection and simultaneous development of their economies (L. Zhang et al., 2019). The interests of corporate entities, enterprises and lawmakers have evolved to encourage and develop new sustainable economic models that can be labeled “green” (Gibbs & O’Neill, 2015). Entrepreneurs are strongly encouraged to engage in green entrepreneurship, which benefits both the economy and the environment. Green entrepreneurship, which combines environmental, social and economic goals, is identified as a viable strategy for establishing a sustainable society (Soomro et al., 2020; Ye et al., 2020).

Global climate change has emerged as humanity’s greatest challenge, affecting both the earth’s natural security and the long-term growth of human society. As a result, lowering GHG emissions and slowing the trend towards climate change have become a significant concern worldwide. Therefore, it is critical to develop an LCE to address long-term economic and environmental issues (H. A. O. Li et al., 2020). The sustainability of the biological ecosystem is threatened by an increase in total CO$_2$ emissions, which also substantially impacts human society. CO$_2$ emissions associated with climate change have long been labeled a “super wicked problem,” severely affecting human well-being (Liu et al., 2020). Firms in developing economies are reluctant to initiate significant green initiatives due to weak rules and regulations that fail to protect against unethical behavior.
and the lack of well-developed communication channels for championing the enormous benefits of green initiatives (Shu et al., 2014; Zhou et al., 2020).

The concept of LCE and renewable energy is vital for all international communities due to the current dual difficulties in the world (the climate crisis and the need for economic development). The international community encompasses entrepreneurs and other key stakeholders who can help ensure a safe environment for human survival (Liu et al., 2020). Alister and Chloé (2020) note that, thanks to proposals to link stimulus packages to battle the coronavirus with a cleaner economy, all governments are under pressure to proclaim more ambitious climate actions within the Paris Climate Agreement’s first five-year milestone. As can be seen from Figure 3, the BRICS countries are widely represented among the world’s major carbon emitters, with all five countries ranking among the top fifteen. Almost two-fifths of the world’s carbon emissions are attributed to BRICS. As a result, environmental sustainability concerns have been raised in the context of the BRICS countries (Wang et al., 2016).

![Territorial CO2 emissions](Global Carbon Atlas, 2019)

**Figure 3.** Top fifteen metric tons of carbon dioxide equivalent (MtCO2) in 2019

Global warming, climatic disasters, and climate transition risks can cause economic crises in developed and developing countries, resulting in increased financial instability, rising volatility of exchange rates, and a slowdown in growth rates (Bolton et al., 2020).
Climate disasters are becoming more common, endangering the lives and livelihoods of millions of people worldwide. Climate risks may force countries to take a path of lower growth marked by greater financial volatility, budgetary limitations, and poverty traps, in addition to a rapid economic and social catastrophe (Semmler et al., 2021). This is especially true for more vulnerable developing countries, many of which have been disproportionately affected by the economic consequences of COVID-19 (Semmler et al., 2021).

During the last BRICS summits in Xiamen 2017 and Johannesburg 2018, the BRICS leaders reaffirmed their decision to take resolute action in dealing with climate change through the Xiamen Declaration and the Johannesburg Declaration. Under the motto of Xiamen “BRICS: Stronger Partnership for a Brighter Future,” the leaders pledged to strengthen BRICS cooperation in the field of climate change and expand green financing, as well as take actions to promote result-oriented cooperation in areas such as air and water pollution prevention, waste management, and biodiversity conservation (Petrone, 2019).

This requires research on further ways to enhance an LCE, especially in the BRICS countries where economic growth is observed. Given the scale of the fight against the terrible effects of climate change in the world, this study is essential. This study contributes to the discussion of multi-level policy, and plans adopted by the BRICS countries to achieve LCE. In addition, to achieve success in reducing the global CO₂ emissions and preventing the catastrophic impact of climate change in the BRICS countries, the governments in these countries, through the effort of various actors, are developing policies that can lead to the achievement of this target. It is necessary that the state decarbonization policy and equitable transition to green economy are coordinated at the international, national, and local levels. Furthermore, this study includes policy recommendations that will help generate fresh ideas for future low-carbon development and guide future practices in tackling CC in the BRICS countries.

This study discusses international, federal, and local climate policies set out by various governments in the BRICS countries to achieve an LCE through a multi-level perspective. Thus, the discussion will cover: fundamentals of the climate change reduction policy, trends and policies in the field of low carbon energy, as well as trends and policies in the field of energy efficiency. In addition, the research examines six important categories of the Climate Action Tracker (CAT) to assess each country’s commitment to the Paris Agreement and the UNFCCC protocols.

The concept of an LCE was initially introduced in the United Kingdom’s White Paper in 2003. LCE aims to increase economic production by reducing CO₂ and GHG emissions (Yin & Shi, 2019). The primary source of climate change is the increase in GHG emissions from human activity, particularly CO₂ emissions. As a result, establishing an LCE has become a universal consensus in fighting against global warming. According to a recent estimate by the Carbon Trust, global low-carbon exports will exceed $1 trillion by 2020 (Baranova, 2017). LCE can be defined as an economic model that aims at the minimum consumption of carbon energy (coal, oil, etc.) and output of GHG, specifically CO₂ (Zhao & Wu, 2010). The World Low Carbon and Eco-economy Conference
and Technical Exposition reports that LCE aims to use high technology, high energy efficiency, high economic benefit, low energy consumption, low pollution, and low emission by stakeholders (Zhao & Wu, 2010).

LCE is defined as “a way of thinking, behaving, and operating that minimizes carbon pollution while allowing for resource sustainability, economic development, and higher quality of life” (Baranova, 2017). Therefore, environmentally sustainable technologies are critical for tackling CC and easing the transition to an LCE (Demirel et al., 2019). The goal of an LCE is to improve the quality of life of people by increasing the efficiency of resource utilization and reducing emissions into the environment. Economic, commercial, and technical shifts will accelerate the need for global LCE. Governments, businesses, and consumers must work together to implement an LCE (Ding et al., 2018; Robertson, 2016; Yan et al., 2019).

2. Materials and methods

2.1. Description of the research area

This study focuses on the BRICS countries (Brazil, Russia, India, China, and South Africa). The abbreviation (BRIC) was created in 2001 to spotlight the growing economies such as Brazil, Russia, India, and China (BRIC), and South Africa was added in 2010, which changed the name of the bloc to BRICS (Morazán et al., 2012). The four participating countries began their annual informal diplomatic cooperation in 2006 when their Foreign Ministers met at the UN General Assembly’s General Debate (UNGA). The BRICS was founded on the member-countries’ long-term economic goals, including revamping the global financial and economic infrastructure, improving international law principles and norms, and promoting complementarity in many sectors of their economy (Kundu, 2016).

The total area of the BRICS countries is 39,746,220 km² (15,346,101.0 sq mi) with a population of approximately 3.21 billion people, accounting for about 26.656 % of the world’s land surface and 41.53 % of its population. With the exception of South Africa, which ranks twenty-fourth in both population and area, four of the five nations are among the world’s ten largest countries in terms of population and size (United Nations, 2019). The BRICS countries were selected for the present study because they expressed concerns about social and environmental resilience. Coordinating the interaction of the environment and the economy and minimizing the global warming impact is crucial for the international sustainable development of the BRICS countries (Dong et al., 2017; Wang et al., 2016).

2.2. Methodological approach

The methodology of this paper is based on data collected from the Climate Action Tracker (CAT) database. The CAT methodically approaches six critical areas in assessing
every country’s commitment to nationally determined contributions (NDC) to the Paris Agreement and the UNFCCC protocols. Table 1 explains these six criteria of the CAT assessment. The Climate Action Tracker (CAT) project was launched in 2009 to provide policy makers, civil society and the media with an up-to-date assessment of countries’ individual emission reduction targets and a global overview of their combined effects. All this is being done in order to make these pledges more transparent and to encourage the participation of those governments that have not yet done so. In addition, the CAT assesses whether countries are on track to meet their commitments in accordance with the current policies (Climate Action Tracker, 2021e).

Table 1. Criteria for nationally determined contributions to the Paris Agreement

<table>
<thead>
<tr>
<th>Nationally determined contributions to the Paris Agreement</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critically insufficient</td>
<td>NDCs with this rating fall outside of a country’s “fair share” range and are not at all consistent with holding warming below 2°C, let alone with the Paris Agreement’s stronger 1.5°C limit</td>
</tr>
<tr>
<td>Highly insufficient</td>
<td>NDCs with this rating fall outside of a country’s “fair share” range and are not consistent with holding warming below 2°C, let alone with the Paris Agreement’s stronger 1.5°C limit</td>
</tr>
<tr>
<td>Insufficient</td>
<td>NDCs with this rating are in the least stringent part of a country’s “fair share” range and not consistent with holding warming below 2°C, let alone with the Paris Agreement’s stronger 1.5°C limit</td>
</tr>
<tr>
<td>Compactible</td>
<td>NDCs with this rating are consistent with the 2009 Copenhagen 2°C goal and therefore fall within a country’s “fair share” range but are not entirely consistent with the Paris Agreement</td>
</tr>
<tr>
<td>1.5°C Paris Agreement Compactible</td>
<td>This rating indicates that a government’s efforts are in the most stringent part of a country’s “fair share” range: it is consistent with the Paris Agreement’s 1.5°C limit</td>
</tr>
<tr>
<td>Role Model</td>
<td>This rating indicates that a government’s efforts are more ambitious than what is considered a “fair share” contribution: it is more than consistent with the Paris Agreement’s 1.5°C limit</td>
</tr>
</tbody>
</table>

Source: (Climate Action Tracker, 2021d).
3. Results

3.1. Brazil

Compared to its fair share contribution to climate action, the CAT rates Brazil’s unconditional 2030 climate target, which begins in December 2020, as “critically insufficient.” The “critically insufficient” rating indicates that Brazil’s 2030 fair share target reflects little to no action and is incompatible with the Paris Agreement’s 1.5°C temperature limit (Climate Action Tracker, 2021a). Brazil’s target is inconsistent with any interpretation of a reasonable approach to meeting the Paris Agreement’s 1.5°C limit. If all countries followed Brazil’s lead, warming would exceed 4°C, as depicted in Table 2 and Figure 3.

Table 2. Brazil’s nationally determined contributions to the Paris Agreement

<table>
<thead>
<tr>
<th>Upper end of `</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critically insufficient</td>
<td>3,000</td>
<td>3,000</td>
<td>3,000</td>
</tr>
<tr>
<td>Highly insufficient</td>
<td>1,495</td>
<td>1,601</td>
<td>1,565</td>
</tr>
<tr>
<td>Insufficient</td>
<td>1,262</td>
<td>1,249</td>
<td>1,137</td>
</tr>
<tr>
<td>2°C compatible</td>
<td>1,034</td>
<td>905</td>
<td>719</td>
</tr>
<tr>
<td>1.5°C compatible</td>
<td>866</td>
<td>651</td>
<td>411</td>
</tr>
<tr>
<td>Role model</td>
<td>568</td>
<td>200</td>
<td>−136</td>
</tr>
</tbody>
</table>

Source: (Climate Action Tracker, 2021a).

Figure 3. Brazil’s nationally determined contributions to the Paris Agreement

Source: (Climate Action Tracker, 2021a).
3.2. Russia

When Russia submitted its NDC update in November 2020, it failed to raise its ambitious goal. The CAT assesses the updated NDC target as “critically insufficient” compared to its fair share of emissions allocated to predicted domestic pathways, as shown in Table 3 and Figure 4. The flimsy target will be easily achieved within the framework of current policies and actions, which the CAT rates as “highly insufficient.” The CAT rates Russia’s climate targets, policies, and financing as “critically insufficient.” (Climate Action Tracker, 2021d).

The “critically insufficient” rating indicates that Russia’s climate policies and commitments represent little to no action and are incompatible with the Paris Agreement. Russia should set a more aggressive emissions reduction target, adopt and implement additional measures, and provide financial assistance to other countries to improve their CAT ratings (Climate Action Tracker, 2021d).

**Table 3.** Russia’s nationally determined contributions to the Paris Agreement

<table>
<thead>
<tr>
<th>Upper end of</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critically insufficient</td>
<td>4,000</td>
<td>4,000</td>
<td>4,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Highly insufficient</td>
<td>2,692</td>
<td>2,597</td>
<td>2,449</td>
<td>1,902</td>
</tr>
<tr>
<td>Insufficient</td>
<td>2,222</td>
<td>2,028</td>
<td>1,848</td>
<td>1,289</td>
</tr>
<tr>
<td>2°C compatible</td>
<td>1,764</td>
<td>1,473</td>
<td>1,261</td>
<td>690</td>
</tr>
<tr>
<td>1.5°C compatible</td>
<td>1,425</td>
<td>1,064</td>
<td>828</td>
<td>248</td>
</tr>
<tr>
<td>Role model</td>
<td>824</td>
<td>337</td>
<td>59</td>
<td>-537</td>
</tr>
</tbody>
</table>

*Source:* (Climate Action Tracker, 2021d).

**Figure 4:** Russia’s nationally determined contributions to the Paris Agreement

*Source:* Climate Action Tracker (Climate Action Tracker, 2021d).
3.3. India

The CAT rates India’s climate targets and policies as “highly insufficient,” indicating that India’s climate policies and commitments do not meet the Paris Agreement’s 1.5°C temperature limit. Compared to a modeled domestic emissions pathway, India’s current targets and policies indicate that emissions will continue to rise and are consistent with warming of 4°C or more. Compared to its fair share contribution to climate action, India’s policies and actions will result in it exceeding its targets, but only by 2°C, as shown in Table 4 and Figure 5.

To improve its rating, India must increase its unconditional NDC target to significantly slow the emissions growth rate. With international assistance, India should also set an ambitious conditional target to reduce the expected increase in emissions due to its dependence on fossil fuels and begin the transition to a net-zero economy (Climate Action Tracker, 2021c).

Table 4. India’s nationally determined contributions to the Paris Agreement

<table>
<thead>
<tr>
<th>Upper end of</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critically insufficient</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
</tr>
<tr>
<td>Highly insufficient</td>
<td>7,116</td>
<td>9,248</td>
<td>11,582</td>
<td>9,541</td>
</tr>
<tr>
<td>Insufficient</td>
<td>5,842</td>
<td>7,318</td>
<td>8,992</td>
<td>7,259</td>
</tr>
<tr>
<td>2°C compatible</td>
<td>4,600</td>
<td>5,434</td>
<td>6,463</td>
<td>5,032</td>
</tr>
<tr>
<td>1.5°C compatible</td>
<td>3,683</td>
<td>4,045</td>
<td>4,597</td>
<td>3,389</td>
</tr>
<tr>
<td>Role model</td>
<td>2,054</td>
<td>1,575</td>
<td>1,281</td>
<td>469</td>
</tr>
</tbody>
</table>

*Source:* (Climate Action Tracker, 2021c).

![India's nationally determined contributions to the Paris Agreement](image)

*Source:* (Climate Action Tracker, 2021c).

**Figure 5:** India’s nationally determined contributions to the Paris Agreement
3.4. China

The CAT rated China as “highly insufficient in its commitment to PA.” China’s climate commitments for 2030 are also rated as “highly insufficient” since emission levels projected under the highest affinity surging and non-fossil share NDC targets are compatible with warming levels from 3°C to 4°C by the end of the 21st century if all countries follow this ambition. The CAT treats China’s NDC pledge as unwavering for this rating system, because it has not indicated a level of ambition that could be achieved with international assistance, as indicated in Table 5 and Figure 6 (Climate Action Tracker, 2021b).

Table 5. China’s nationally determined contributions to the Paris Agreement

<table>
<thead>
<tr>
<th>Upper end of</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critically insufficient</td>
<td>18,000</td>
<td>18,000</td>
<td>18,000</td>
<td>18,000</td>
</tr>
<tr>
<td>Highly insufficient</td>
<td>17,411</td>
<td>16,627</td>
<td>16,910</td>
<td>16,033</td>
</tr>
<tr>
<td>Insufficient</td>
<td>14,486</td>
<td>13,863</td>
<td>13,776</td>
<td>12,113</td>
</tr>
<tr>
<td>2°C compatible</td>
<td>11,629</td>
<td>11,166</td>
<td>10,715</td>
<td>8,285</td>
</tr>
<tr>
<td>1.5°C compatible</td>
<td>9,522</td>
<td>9,176</td>
<td>8,458</td>
<td>5,462</td>
</tr>
<tr>
<td>Role model</td>
<td>5,777</td>
<td>5,639</td>
<td>4,446</td>
<td>444</td>
</tr>
</tbody>
</table>

Source: (Climate Action Tracker, 2021b).

Figure 6: China’s nationally determined contributions to the Paris Agreement

3.5. South Africa

Table 6 and Figure 7 depict South Africa’s efforts to contribute to the Paris Agreement to reduce emissions. South Africa was classified by the CAT as “highly insufficient” in terms of the countries fair share of contribution to the NDC target set by the Paris Agreement.
The implication is that South Africa falls out of its fair share and its NDC contributions are inconsistent with the PA agreement. The “highly insufficient” range means that if most countries fall within this category, global warming will reach from 3°C to 4°C. South Africa’s 2030 emissions reduction target is rated as “insufficient” compared to predicted domestic pathways and “highly insufficient” compared to its fair share contribution to climate action. South Africa’s targets and policies are insufficient to keep warming to 1.5°C.

### Table 6. South Africa’s nationally determined contributions to the Paris Agreement

<table>
<thead>
<tr>
<th>Upper end of</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critically insufficient (end of graph)</td>
<td>2,400</td>
<td>2,400</td>
<td>2,400</td>
<td>2,400</td>
</tr>
<tr>
<td>Highly insufficient</td>
<td>679</td>
<td>656</td>
<td>684</td>
<td>724</td>
</tr>
<tr>
<td>Insufficient</td>
<td>592</td>
<td>560</td>
<td>559</td>
<td>539</td>
</tr>
<tr>
<td>2°C compatible</td>
<td>508</td>
<td>467</td>
<td>437</td>
<td>357</td>
</tr>
<tr>
<td>1.5°C compatible</td>
<td>445</td>
<td>398</td>
<td>348</td>
<td>224</td>
</tr>
<tr>
<td>Role model</td>
<td>334</td>
<td>275</td>
<td>188</td>
<td>−13.6</td>
</tr>
</tbody>
</table>

*Source: (Climate Action Tracker, 2021e).*

### Figure 7: South Africa’s nationally determined contributions to the Paris Agreement

### 4. Discussion

#### 4.1. Multilevel policy to reduce carbon emissions in the BRICS countries

This paper provides an overview of the strategy adopted by the BRICS countries to reduce carbon emissions. The BRICS summits and meetings of environment ministers supported
the UN in the field of CC, in particular, the intensification of the activities of the G20 and UN summits in the field of sustainable development, CC, and biodiversity. The UN has received similar support from the majority of BRICS summit commitments. Improving collaboration and continuing the exchange of knowledge to reduce the adverse effect of CC on food security and agriculture is one of the aims of the BRICS countries (Kirton, 2020). The study delves into three recent policies adopted by each government in the BRICS countries to address CC issues, GHG, carbon emission, and general environmental problems. This section provides insight into the aims and objectives of some of these projects and policies, as well as how they can lead to an LCE in the BRICS countries.

4.2. Brazil’s pathway to a low carbon economy

Brazil is among the five significant emerging BRICS countries, and it ranks sixth in the world in terms of GHG emissions (Scarano & Ceotto, 2015). In the run-up to the Paris climate change summit, Brazil boosted the ambition of its climate initiatives through various programs and activities (Scarano & Ceotto, 2015). Green finance tools, such as green bonds and green loans, can channel vast private capital towards climate and environment-friendly investments. Investors commit to climate-related projects by expanding the use of renewable energy, improving energy efficiency, and adapting to CC. The Ministry of Mines and Energy (MME) and the Brazilian Energy Research Company have launched the 2050 National Energy Plan (PNE 2050). The MME coordinates the program, supporting construction, appliances, and manufacturing efforts. Other more recent measures emphasizing energy efficiency include the MME’s (PNE 2030), which estimates that by 2030, Brazil will cut its energy use by 10%. The MME is currently working on the PNE 2050 National Energy Plan, which is likely to be completed shortly (Nachmany et al., 2015). Analysis and estimates of economic development, energy demand and output potential will be used to pursue energy policy for the next 30 years (Nachmany et al., 2015).

The Executive Committee for the Control of Illegal Deforestation and the Recovery of Native Vegetation was established by a Government Decree comprising 12 articles. It outlines the above committee’s composition, tasks, and responsibilities, proposing planning, formulation and integrating strategies to prevent and control illegal deforestation and native vegetation recovery (da Silva et al., 2020). Forest legislation was defined as a system of laws regulating the exploitation and utilization of forest resources. The plan aimed at protecting regions or resources in Brazil dates back to the colonial period, with the primary goal of ensuring control over the management of certain objects, such as flora, water, and soil (Castelo, 2015)

4.3. Russia’s pathway to a low-carbon economy

Russia saw its emissions nosedive after the Soviet Union’s smokestack industries fell in 1991 (Safonov, 2021). The country’s production is still less than it was in 1990, reducing CO₂ emissions compared to the UN’s benchmark. Russia started to fight CC back in the
1980s. By the late 1980s, climatologists reached a consensus on human contributions to current global warming, resulting in the 1992 ratification of the UNFCCC. The Soviet Union has always been a leading voice on the climate agenda (Safonov, 2021). Russia has been actively involved in international climate negotiations for more than two decades within the framework of the United Nations, the G8 and G20, and the BRICS bloc, including the UNFCCC and the Paris Agreement’s commitment to avoid “dangerous interference with the climatic system” and achieve net-zero carbon emissions by 2050 (Climate Action Tracker, 2018).

In June 2020, the Russian government approved a new Energy Strategy until 2035. The strategy states that one of Russia’s primary objectives is to become a global leader in hydrogen production and use. It also sets concrete goals for the export of hydrogen, which should amount to 0.2 million tons by 2024 and 2 million tons by 2030 (Mitrova & Yermakov, 2019). To meet these goals, the government plans to undertake the following measures (Frolov, 2021):

- investments in production, transportation and consumption of hydrogen and hydrogen-based energy mixes
- increase of natural gas-based hydrogen generation, including using renewable and nuclear energy
- development of Russian low-carbon technologies for producing hydrogen by methane pyrolysis, electrolysis, and other methods, including by localization of foreign technologies
- internal market demand for hydrogen fuel cells in transportation, as well as use of hydrogen and hydrogen-based energy mixes as energy storage and a conversion tool to increase efficiency of centralized power supply systems.

On January 4, 2020, Russia issued a comprehensive strategy for adapting its economy and society to climate change. The Russian government published a National Action Plan for the First Phase of Climate Change Adaptation for up to 2022. The statement lays out steps that federal and regional governments will take to lower the economy’s effect on natural environment’s susceptibility to climate change impacts. Furthermore, it identifies several potential opportunities that may arise due to climate change (Devyatkin, 2020). This national plan lays out economic and social measures that will be implemented by federal and regional executive bodies to reduce the vulnerability of the Russian population, economy, and natural resources to CC’s effects, as well as seize the opportunities that such changes present. This authorized national plan is the first step in adapting the economy and the population to CC. It includes structural, organizational, and methodological strategies to help develop CC adaptation solutions (Ingram, 2020).

4.4. India’s pathway to a low-carbon economy

India’s energy future is important for both global and national development goals. India’s existing and projected emissions are significant enough to impact international mitigation efforts (Dubash et al., 2018). India’s multi-level energy and climate governance framework includes the national level, federal states, and cities, each with its own set of
obligations, challenges, and opportunities. It can be argued that since India’s economic liberalization in 1991, its states have grown in importance and have become critical stakeholders in the country’s multi-level energy and climate governance frameworks (Jørgensen & Wagner, 2017).

India’s Ministry of Environment, Forests and Climate Change (MoEFCC) has formed a high-level inter-ministerial Apex Committee for Implementation of the Paris Agreement (AIPA), confirming the country’s commitment to go to CC “step by step” (Sangomla, 2020). AIPA intends to provide a coordinated response to CC concerns so that India keeps up with its Paris Agreement obligations, especially its nationally determined contributions (NDC). AIPA will also act as a national authority to regulate carbon markets in India under Article 6 of the Paris Agreement. AIPA will also issue guidelines on carbon pricing, market mechanisms, and other similar instruments that affect CC and NDCs. It will assess the business sector’s and multilateral agencies’ contributions to CC and provide recommendations on better aligning their climate actions with national priorities (Sangomla, 2020).

The Ministry of New and Renewable Energy has created this program to assist farmers with financial incentives to switch from fossil fuel-powered pumps to new solar-powered machinery. The primary goal of this program is to make farmers economically self-sufficient. Farmers will be allowed to install solar plants on their farm’s idle land either by themselves or in partnership with an investor under the initiative, which will allow them to earn a regular income (Bhopal, 2021).

The National Action Plan on Climate Change (NAPCC) addresses urgent and critical concerns of the country by changing the direction of development, including enhancing the current and planned activities outlined in the technical document (NAPCC, 2021). The NAPCC also presents several steps to simultaneously advance India’s development and CC-related objectives of adaptation and mitigation. The NAPCC lists eight national climate change missions: (1) National Solar Mission; (2) National Energy Efficiency Mission; (3) National Mission on Sustainable Habitat; (4) National Water Mission; (5) National Mission for Sustaining the Himalayan Ecosystem; (6) National Mission for a Green India; (7) National Mission for Sustainable Agriculture; (8) National Mission on Strategic Knowledge for Climate Change (Firstpost, 2021; NAPCC, 2021).

4.5. China’s pathway to a low-carbon economy

China surpassed the United States as the world’s leading GHG producer in 2007, accounting for approximately 28–30% of total worldwide emissions (Heggelund, 2021). China’s significant emissions can be attributed to its huge size of about 1.4 billion people, as well as its second-largest economy, largest export of products, most significant energy consumption and largest energy import. China has made remarkable economic progress over the past three decades, with a fast growth rate and an increase in annual GDP (Y. Li et al., 2020; Wei et al., 2018). China’s export is predominantly focused on value-added intermediate goods and processing trade. Y. Li et al. (2020) argue that rapid economic expansion leads to very high energy consumption and carbon emissions per GDP. Wei et al.
Analysis of the BRICS countries’ pathways towards a low-carbon environment

(2015) observe that, according to forecasts, China will face sustainable demands to reduce CO₂ emissions in the medium and long term due to the country’s current economic situation. China must find long-term solutions to achieve an LCE while maintaining an appropriate economic growth rate. In 2005, the Chinese government announced that by 2020, emissions of CO₂ per unit of GDP would be reduced by 40% to 45% (Y. Li et al., 2020).

The National Development and Reform Commission has developed a draft environmental legislation. It intends to improve the internal investment management, reinforce and standardize the central budget for pollution control, energy conservation and CO₂, and mobilize “social capital” to participate in pollution control, energy conservation, and CO₂ reduction. This document is intended to replace Interim Measures for the Special Management of Investment in Ecological Civilization Construction within the Central Budget (Climate Change Laws of the World, 2021).

This working report describes a path to carbon neutrality by 2060 with emissions peaking by 2030 as China ramps up efforts to decarbonize its economy. The government has set a goal to reduce energy intensity by about 3% by 2021. Over the next five years, the authorities intend to reduce energy intensity by 13.5% and carbon intensity by 18%. According to this report, an “action plan” for achieving peak carbon emissions will be developed by the end of the decade (Ashwin Kaja, 2021). The 14th Five-Year Plan lays out China’s development goal and roadmap for 2021–2025, as well as concrete environmental and efficiency targets. The strategy reaffirms the previously stated goal of carbon neutrality by 2060 and sets a target for reaching peak emissions in 2030 (Cooper, 2021; Xinhua News Agency, 2021).

The New Energy Vehicle Industry Development Plant aims to help the country produce electric and fuel cell automobiles. The 2020 New Energy Vehicle (NEV) Promotion Subsidy Plan provides for governmental support for the electrification of vehicles in the areas of public transportation, urban public transport, road passenger transportation, rental (including online car-hailing), environmental sanitation, urban logistics and distribution, postal express, civil aviation, airport and party transportation for the period from 2020 to 2022 (Chu, 2021). China’s Plan for 2021–2035 aims to put the country in a position to meet the future demand for autonomous, connected, electrified and shared mobility. Its three main objectives are:

- establishing a globally competitive auto industry with advanced NEV technologies and a positive brand reputation
- transition to an energy-efficient and low-carbon society with a convenient charging service network and battery-powered electric vehicles as the main sales direction
- improving national energy security and air quality, mitigating climate change and stimulating economic growth (Chu, 2021).

4.5. South Africa’s pathway to a low-carbon economy

In light of the growing need for CO₂ emissions and realizing potential benefits of a green-based society, the South African government has established plans to reduce carbon
emissions by 34% and 42% by 2020 and 2025, respectively (Ganda & Milondzo, 2018). Climate change is having a significant influence on South Africa, considerably increasing the temperature and water variability. The rate of global warming recorded in the west and northeast is 2°C per century or more, which is more than twice the worldwide temperature increase (Gazette, 2020). By 2030, the National Development Plan (NDP) of South Africa intends to eradicate poverty, protect the environment, and promote economic development (Vinet & Zhedanov, 2011). South Africa is a signatory to the Paris Climate Change Agreement and has ratified it. South Africa’s emissions are predicted to peak, plateau and decline beginning in 2025. The energy industry is responsible for about 80% of the country’s total GHG emissions, with half of this volume coming from power generation and liquid fuel production (Ziervogel et al., 2014). Three of the most recent policies outlined by South Africa to achieve LCE are discussed below.

South Africa’s economic reconstruction and recovery plan aimed at fostering equitable and inclusive growth was launched in October 2020. Many of proposed measures could help South Africa adapt to CC and reduce CO₂ emissions, bringing long-term social and economic benefits (Modise, 2021). On March 24, 2021, the government enacted a revised draft of the nationally determined contributions (NDC), the basis of South Africa’s CC response. Under the UNFCCC and the Paris Agreement, South Africa has agreed to contribute to the global CC effort (Modise, 2021). Green recovery initiatives and more aggressive action on climate change can complement each other to reduce GHG emissions, build resilience and boost economic growth. Countries can think about how these recovery actions will help them improve their NDCs and meet the long-term goals of the Paris Agreement, which is essential with the approach of the COP26 in Glasgow (World Resources Institute, 2021).

South Africa’s National Climate Change Adaptation Strategy (NCCAS) puts forth a coherent vision of adaptation and resilience to CC and critical sectors for achieving that vision (Department of Environmental Affairs, 2016). As stipulated in the Paris Agreement, the NCCAS serves as South Africa’s National Adaptation Plan and demonstrates its commitment to its international obligations under the UNFCCC. The NCCAS will serve as the foundation for fulfilling South Africa’s adaptation responsibilities under the nationally determined contributions (Department of Environmental Affairs, 2016). The South African Department of Energy has released an Integrated Resource Plan that predicts the country’s estimated energy demand for the next 20 years, from 2010 to 2030. The IRP is a capacity plan for energy that attempts to estimate the country’s electricity demand, how it will be supplied and how much it will cost. The Department of Energy envisions the IRP as a “life plan” that will be regularly revised (Hofmeyr, 2021).

5. Policy recommendations for the BRICS countries’ transition to an LCE

This section discusses several strategies and recommendations for the BRICS countries’ pathway to an LCE (Figure 9). These strategies can also be applied at various scales to reduce CO₂ emissions in the BRICS countries.
5.1. Expanding low-carbon investments and financing in the BRICS countries

There is a unique opportunity to ensure that new infrastructure investments serve the climate agenda while also encouraging economic development, and this is urgent and unprecedented. For the BRICS regions, additional short-term costs of switching to a low-carbon energy system will account for only a small fraction of the overall infrastructure financing required (OECD/IEA/NEA/ITF, 2015). If the BRICS governments reevaluate their support for investments in greenhouse-gas-intensive activities and mainstream climate objectives into public procurement and official development assistance, public finance and investment can also catalyze the low-carbon transition. Public finance is just one of several tools that can facilitate the transition, such as infrastructure development, cleaning up sites, training and retraining. An essential part of creating a transition strategy is identifying potential investors and entrepreneurs in the region who may be willing to make the most effective use of public financing (Kustova et al., 2021).

Focus on taxation extends beyond energy. The most frequently researched environmental tax mechanisms are taxes on particular activities or consumption that generate highly damaging emissions, effluents or residues, such as energy taxes and carbon taxes (Vence & López Pérez, 2021). While subsidies and tax expenditures favoring the development and use of fossil fuels impede low-carbon innovation, the current low oil prices also
present a chance for reforms. In addition, governments in the BRICS regions can provide tax incentives and subsidies to organizations or entrepreneurs who are engaged in green business. Howard et al. (2021) note that an economy-wide carbon tax and government commitments to global action to reduce CO₂ emissions are other ways to reduce cross-sectoral leaks in the economy.

**Investment in low-carbon cities.** As a concept of urban development, low-carbon consumption and production in cities can help create more cost-effective and environmentally-friendly urban energy and ecological systems. Reduced greenhouse gas emissions and minimal energy use are required in low-carbon cities (M. Zhang, 2021). Cities play a significant role in global greenhouse gas emissions, especially urban regions, which account for 67–76% of worldwide CO₂ emissions and energy consumption (Han et al., 2020). Cities have evolved into fundamental units for implementing measures to reduce emissions. Reduced greenhouse gas emissions and low energy usage are required in low-carbon cities in addition to a focus on economic development. To create a win-win situation between urbanization and environmental protection, it is necessary to change traditional energy technologies and introduce innovations to limit the consumption of high-carbon energy and the production of urban greenhouse gases (M. Zhang, 2021). Therefore, the study recommends that the various governments in the BRICS should invest more in low-carbon cities, leading them to an LCE. Yang et al. (2019) add that after 2009, many cities released their plans for low-carbon economic development and low-carbon city construction. Low-carbon pilots, sponge cities, low-carbon community pilots, and national low-carbon city (town) pilots are primarily responsible for achieving low-carbon cities.

**Adapting to circular economy and low-carbon technology.** A circular economy is a business model that highlights the ecosystem’s regenerative capacity by reducing the consumption of non-renewable resources, extending the usable life of commodities, and reusing all materials that enter the economic cycle to reduce waste and pollution (Vence & López Pérez, 2021). Low-carbon technology will become more widely used as solutions become more mature in the market. The transition to clean and secure electricity will lay the groundwork for end-use electrification, which is one of the main priorities (IAEA, 2021). Low-carbon technology is one of the specialized methods of reducing carbon dioxide emissions in buildings. Low-carbon technology emits the least amount of GHGs into the environment, in particular CO₂ (Ali et al., 2020). Evaporative cooling, passive ventilation and cooling, solar photovoltaic, dehumidification, and energy recovery systems are examples of renewable and sustainable energy technologies (Ali et al., 2020).

**The BRICS countries should expand electricity markets.** To achieve effective decarbonization of energy systems, electricity must be used. On the other hand, deregulated electricity markets do not provide a long-term price signal for investments in high-capital-cost low-carbon technologies. New market arrangements, such as long-term supply agreements, as well as a robust and steady CO₂ price signal, will be needed to ensure competitive and timely investment in low-carbon solutions. To stimulate investment in low-carbon technologies, jurisdictions with regulated systems should consider providing greater competition (OECD/IEA/NEA/ITF, 2015).
Promoting climate-friendly international trade among the BRICS countries. Although the international trade regime does not restrict states from implementing aggressive climate measures, some international trade barriers may undercut climate goals. Import restrictions, for example, continue to penalize trade in some technologies required for the low-carbon transition. Many countries that promote greener growth by favoring domestic manufacturers of low-carbon technologies must exercise caution. Where these regulations impede international trade, they may have a negative impact on total investment and the adoption of sustainable technologies (OECD/IEA/NEA/ITF, 2015). The BRICS countries’ pathway to LCE can be successful through the promotion of climate-friendly trade among themselves.

Conclusion

The discussion above shows that various governments in the BRICS countries have taken measures to control CC and its consequences on people. All these policies are aimed at achieving an LCE, which is highly recommended. However, the critical issue that needs to be addressed is the implementation of such policies. This will require strict measures to monitor the practical evaluation of the plans and procedures in the BRICS countries to achieve the target of an LCE. The study discusses Brazil’s policies, which include the National Energy Plans for 2030 and 2050 and the Plan to Control Illegal Deforestation and Recovery of Native Vegetation that provides for the establishment of the Amazon Fund. Russia also adopted Energy Strategy 2035 for Russia, which approved the hydrogen roadmap 2021–2024 for Russia, and the National Action Plan for the First Phase of Adaptation to Climate Change. India’s actions and plans also include Apex Committee for Implementation of the Paris Agreement of India, the Prime Minister’s Farmer Energy Security and Upliftment Campaign, and the National Action Plan on Climate Change. China has also implemented these strategies: Pollution Control, Energy Conservation and Carbon Reduction, The 14th Five-Year Plan, and The New Energy Vehicle Industry Development Plan. South Africa’s initiatives include the Economic Reconstruction and Recovery Plan, the National Climate Change Adaptation Strategy, and the Integrated Resource Plan. The study advocates that the BRICS counties can achieve an LCE through expansion in low-carbon investments and financing, focus on taxation that extends beyond energy, investment in low-carbon cities, adaptation to a circular economy and low-carbon technologies, expanding electricity markets, and promotion of climate-friendly international trade among the BRICS countries.

Abbreviations

LCE — low-carbon environment; CC — climate change; GHG — global greenhouse gas; IPCC — Intergovernmental Panel on Climate Change; IPBES — Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services; UNFCCC — United Nations Framework on Climate Change; MAPA — Brazil’s Ministry of Agriculture,

**Acknowledgment**

The authors express their gratitude to Mr. Kwasi Agyemang for his immense contribution to the editing of this article.

**References**


Effectiveness of forbearance measures for Russian commercial banks in the current crisis

Olga Vinogradova,*
Faculty of Economics, Lomonosov Moscow State University (Russia)


Abstract
Due to the COVID-19 pandemic, real GDP of Russia is expected to fall by 4–6%. The banking industry provides liquidity to Russian business in times of hardship. On the one hand, the Bank of Russia facilitates lending opportunities for the business and subsidizes the mortgage interest rate for banks and the public in order to prevent business bankruptcies. And on the other hand, it provides liquidity to banks via REPO (repurchase agreement) auctions. Currently, there is not enough demand for REPO transactions from banks, but it might increase after other measures of support begin to be canceled. The article studies the effectiveness of current forbearance measures for Russian banks and provides an insight into the future development of the banking industry after the COVID-19 pandemic.

Keywords: banking sector, commercial banks, COVID-19 pandemic crisis, forbearance measures, liquidity, REPO.

JEL: G21, G28, G29.

Introduction
The current economic crisis caused by COVID-19 has put banks in Russia on high alert as banking standards remain the same, but the crisis is undermining lenders’ ability to pay off their mortgages and loans. Already in March 2020, the government of Russia came up with a number of supporting measures and recommendations to commercial banks. The goal of the article is to evaluate the effectiveness of the state support measures to Russian commercial banks in the current crisis and recommend further actions and changes to support and develop the banking sector.

* E-mail: o.s.gluhova@mail.ru
In March 2020, the Bank of Russia recommended commercial banks to soften the conditions of loans to people. At the same time, the Bank of Russia grants indulgences when checking accounts of banks according to the national requirements. All measures are aimed at increasing lending to the economy in a crisis. Initially, the measures of support included the following:

- temporary cancellation of capital premium requirements
- benefits for banks when revaluing shares and bonds in their asset portfolios
- the possibility for banks to use the old ruble rate when calculating portfolios of assets for their basic standards and requirements.

The first challenge for the banks is the loss of capital due to the ruble devaluation after the fall in oil prices. Russian banks that have a large amount of debt securities on their balance sheet bear the greatest risk. The state-owned Otkritie Bank\(^1\) has a volume of securities on its balance sheet exceeding 250% of its own funds under IFRS, and RSHB\(^2\) (Russian Agricultural Bank) is approaching 200% of its own capital. Otkritie and RSHB are the leading banks in Russia and are most vulnerable to the current volatility in the market based on these criteria. These banks could not hedge their debt securities because hedging did not work in this soft market.

The current challenges of banks are clear — oil prices, rubles devaluation, asset revaluation, financial shocks in the global market, business disruptions, and cheap credit. The next challenge is potential credit losses and an increase in reserves due to an increase in bad debts and a decrease in the quality of loans. This paper evaluates how the five largest Russian banks can respond to these challenges and what risks exist in the current crisis. As a result, support measures and their effectiveness will be assessed.

1. Materials and methods

The following officially announced by the Bank of Russia measures of support are considered to be the main ones affecting the positions of banks and important for this research:\(^3\)

- the Bank of Russia entitles credit institutions not to recognize loans as restructured for the purpose of creating reserves and not to apply macroprudential add-ons to such loans
- entitles credit institutions not to increase reserves on loans to individual borrowers of the Bank of Russia in case of worsening of their financial standing and/or the quality of debt servicing
- allows credit institutions to include operations in six foreign currencies (US dollar, pound sterling, Swiss franc, Japanese yen, and Chinese yuan) in their required ratios calculations (excluding calculations of the values (limits) of open currency positions) at the official exchange rate of the respective currency

---

\(^1\) https://ir.open.ru/reports?from=footer&_ga=2.226954717.1726678754.1598033634-140232270.1598033634

\(^2\) https://www.rshb.ru/investors/msfo/

\(^3\) http://www.cbr.ru/eng/press/pr/?file=23032020_170800eng2020-03-23t17_07_10.htm
• maintains the national countercyclical capital buffer at zero per cent
• limits the application of administrative sanctions primarily for non-compliance with reporting deadlines, violation of corporate legislation, and violation of legislation on credit history bureaus.

These measures are of primary importance for supporting the economy and commercial banks in the current crisis. The bond market was not affected. The banking system has seen the structural liquidity surplus since 2017 and remained in that position. Nevertheless, the Bank of Russia had to provide markets with extra ruble liquidity through regular short-term fine-tuning REPO to relieve stress from spikes in margin payments and an increase in demand for cash in circulation amidst the lockdown. Even though the banking system retained a structural liquidity surplus, the distribution of this liquidity is uneven, and shifts in the assets and liabilities of banks’ balance shifts in the conditions of lockdown and loan reprofiling complicate their liquidity management in the interim period.

As noted before, the Bank of Russia terminated capital buffers and introduced a number of temporary regulatory forbearance measures to support debt restructuring and prevent procyclical behavior of the financial system. Currently, macroprudential buffers in the system are sufficient to compensate for losses.

The Bank of Russia introduced REPOs for 1 month and 1 year (with a narrower pool of collateral than its regular operations) to assist banks during this period and reduce the need for the use of fine-tuning operations. However, there were no orders from banks during the first REPO, which confirms that the liquidity conditions in the banking sector are quite normal currently. The Bank of Russia also increased the limit of standing FX swap facility, which was similarly not tapped by the market. Using the Bank of Russia’s REPO statistics, statistics of the banking sector, and bad debts statistics in the banking sector, the author analyzes the recent measures and compares them to the past measures introduced during the crisis of 2014–2015.

Despite all this, in 2020 the Moody’s rating agency has lowered the outlook for Russia’s banking system from stable to negative as banks’ asset quality and profitability is expected to deteriorate and real GDP is expected to fall by 4–6%. This decision is continued up to this day. Therefore the situation requires a closer look at the measures which have been introduced to counteract the slump.

2. Theoretical approach

There is a lot of literature on the topics of financial crises, but, as Reinhart and Rogoff say in their book, “This time is different,” which means that each crisis is special, and we cannot predict the consequences (Reinhart & Rogoff, 2009). The only thing we can do is evaluate the latest financial positions of banks and see how support measures affect the financial situation on a time scale. The Bank of Russia’s policy of macroeconomic

---

4 https://www.moodys.com/research/Moodys-takes-rating-actions-on-four-banks-in-Russia--PR_422928
regulation and the effectiveness of its implementation are related to the problem of irrational behavior of microeconomic subjects (commercial banks) and the asymmetry of information distribution.

The theoretical prerequisites for the irrationality were highlighted in the work by D. Kahneman and A. Tversky (1979, 1986, 2013). The biological reasoning behind the abundance of irrationality arises as an interdisciplinary field that uses neuroscience tools to describe the state of market bubbles and economic phenomena (Lo, 2011; Rangel et al., 2008, Brennan et al, 2011). J. Zweig links economic irrationality with addiction to predicting. It seems possible to achieve some kind of perfection if you predict the further. Real rationality cannot exist for humans (due to a gap between computers and humans) because of their desire to control random processes (Zweig, 2007). The theory of rational irrationality assumes systemic biases to repetitive decisions (predictably irrational). This leads to a transformation of the meaning from optimal basis to systemic preference (Adland & Cullinane, 2005). Based on rational irrationality, we can explain the unknown and changing part of economic development.

The problem of information distribution asymmetry enhances the irrationality of economic decisions. Signaling theory explains how signals penetrate and are distributed between agents. The essence of signaling theory is that some agent transmits some information to the principal. Signaling theory developed on the basis of empirical data on the incompleteness of the information received (Akerlof, 1970; Stiglitz, 1979). The interdependence of signaling theory and the theory of irrationality is described in a work by L. Weber and K. Meyer. The authors identified the need for agents to take into account the problems of distorted perception of macroeconomic signals when making rational decisions (Weber & Meyer, 2010).

For this article, the author analyzed policy measures introduced by the Bank of Russia and the reaction of banks to these measures.

**REPO as a means of support.** Since the 2014 crisis, the first long-term REPO auction designed to stabilize liquidity in the banking sector with a minimum interest rate equal to the central bank’s key rate plus 0.1 percentage points was held on May 25, 2014. The first REPO auction for 500 billion rubles (with interest rate 5.6% per annum) did not take place due to lack of demand from banks, which suggests that banks had enough liquidity by that time. The second attempt of a one-year REPO auction was held on June 22, 2014, with a floating rate equal to the key rate plus 0.25 percentage points. Since then, long-term REPO auctions were held every month to support bank liquidity. The collateral for these REPOs was government bonds and municipal bonds with the highest credit rating.

**Liquidity vs. profitability.** Banks have to sacrifice profitability to have enough liquidity. The “liquidity cushion” in banks is mainly formed by the assets of legal entities in bank accounts. Credit institutions, especially medium-sized and small ones, are forced to support their liquidity rather than place their assets for profitability. According to the Central Bank, on May 22, 2014, the structural liquidity surplus in the banking sector was 1.54 trillion rubles. This is equal to the April liquidity surplus after banks experienced a serious outflow of deposits in March.
The monthly REPOs were not in sufficient demand among banks, but one-year REPOs can become a source of additional marginal profitability for banks instead of funding classic lending operations. In the current crisis, the number of new loans is decreasing as risk management is tightening. It is highly possible that the funds attracted in the framework of REPO auctions will not become a driver of a decrease in lending growth rates. But they will support the banks’ income base, taking into account the reduction in interest income on traditional lending operations.

\[\text{Source: } http://www.cbr.ru/statistics/rcb/\]

**Figure 1.** Debt securities owned by Russian banks transferred as part of REPO transactions with the Bank of Russia (million rubles) from 2018 to 2020

The REPO volume has decreased significantly compared to 2016. In 2018, the total amount of REPO was small and the banks had enough liquidity, but in 2020 and 2021, due to the crisis, they had to go for long-term REPOs in April 2020 and May 2020. Meanwhile these figures are not comparable with the REPO volume back in 2013–2017 when it reached 4,173 billion rubles in May 2015 (Figure 2).

REPO is intended to provide liquidity to Russian commercial banks through tri-party REPO trades with the Bank of Russia, involving NSD’s collateral management services (CMS). The purpose of the REPO is to offer more trading and settlement opportunities to market participants and help them reduce their costs.

The Bank of Russia’s REPO trades with a securities basket were launched on April 15, 2013, and any Russian credit institution that satisfies the Bank of Russia’s eligibility requirements can use the service. REPO trades can be made only on behalf and at the expense of the credit institution itself, and only the owner’s securities accounts can be used for allocation and settlement of securities.

With effect from January 1, 2017, the Bank of Russia introduced a new standard form of a universal master agreement, according to which it is possible to enter into on-

exchange REPO trades with the Bank of Russia with a basket of RUB/USD-denominated securities. On June 19, 2017, the Bank of Russia’s REPO trades using NSD’s collateral management services were launched on the Moscow Stock Exchange.

The volume of REPO trades was 2,554 billion rubles in October 2013 and reached 3,354 billion rubles in January 2016, then the volume of REPO began to decrease (Figure 2).

![Figure 2. Debt securities owned by Russian banks transferred as part of REPO transactions with the Bank of Russia (million rubles) from 2013 to 2016](http://www.cbr.ru/statistics/rcb/)

The volume of REPO trades was 2,600 billion rubles in October 2016 and began to decrease to very low volumes in 2017 (Figure 3).

![Figure 3. Debt securities owned by Russian banks transferred as part of REPO transactions with the Bank of Russia (million rubles) from 2016 to 2019](http://www.cbr.ru/statistics/rcb/)
No need to say that in 2014–2015, the crisis REPO was a very valuable source of eliminating the liquidity disbalance. In 2020, the banking sector was handling the situation with its own liquidity surplus, keeping clients’ assets in access rather than investing them for marginal profits, and as a result, the volume of repos traded was significantly lower than during the 2012–2015 crisis, which showed that Russian banks had enough liquidity by that time.

How can indirect non-banking measures affect the banks? In crisis times, risk management becomes the most vulnerable sphere of the banking industry. The consequence of higher standards when approving loan decisions is a decrease in loan volumes provided by financial institutions to public and legal bodies. Higher standards of risk management lead to lower margins and profitability during a crisis. Meanwhile, the quality of banks’ credit portfolios is declining as customers suffer from low demand, and as a result, banks have to add reserves for their financial statements. That is why financial aid provided to corporates and different sectors of the economy indirectly affects the banking sphere and increases its financial strengths if the measures are adequate and effective.

Lower borrower rate. The key instruments of financial support are bank loans at reduced interest rates for SMEs and other borrowers. The state partially compensates banks for interest losses via subsidies. The Bank of Russia has introduced regulatory reliefs for credit institutions in order to encourage loan restructuring and has expanded its refinancing programs for SME loans.

If a person is diagnosed with Covid-19, the bank at which this person has a credit is now allowed to charge him extra fee till the end of 2020, and banks must not use his or her property for a repayment scheme. Meanwhile, the bank may receive money and subsidies for restructuring its own portfolio.

Bank loans for systemically important companies at reduced rates. Bank loans for working capital can be provided to systemically important companies for up to 12 months and for no more than 3 billion rubles per each borrower. The interest rate cannot exceed 5%. The state will cover the banks’ loss of interest through subsidies. Borrowers can also apply for state guarantees to secure repayment of the loan.

The government plans to support systemically important companies on an individual basis and will provide individual support to systemically important companies when their owners and banks exhaust their own ability to support the company for the first time.

Interest-free bank loans to cover wage payments in SMEs. Companies can apply for a credit to pay wages to their employees for a period of six months. Banks are entitled to state subsidies to compensate for the loss of interest on such loans for a six-month period. The amount of the loan depends on the minimum statutory monthly wage and the number of employees. But SMEs are not allowed to dismiss more than 10% of their employees during this six-month period.

Credit holidays for individuals and SMEs. This project has previously been widely discussed by the Bank of Russia. The main reason that stopped this project was: Who will compensate for the credit holidays while people are not paying? COVID-19 pushed the project forward without much further thought. Lenders suspended payments
on mortgages and other loans for up to six months — until September 30, 2020. Instead of a deferral, entrepreneurs can seek a reduction for payments during the grace period. Penalties are not accrued during credit holidays. In order to be eligible for credit holidays, individuals had to lose more than 30% of their income compared to their average monthly income in 2019.

Subsidies to banks to support grace periods for SMEs. The state provides subsidies to banks that have granted SMEs operating in the most affected sectors a grace period for up to six months (in relation to loans granted before April 1, 2020). The number of subsidies is limited to one third of the interest payments due from a SME-borrower during the grace period. The borrower is to pay one third of the interest payments due for the grace period and is released from paying the remaining two thirds.

Bank loans to support the construction sector. The construction sector is less reliable but it is one of the most profitable in Russia. Meanwhile, it has the highest percentage of bad debts among other sectors of the economy. It was expected that many construction companies could go bust, as the process of construction stopped during COVID-19. But the construction sector sacrificed marginal returns and started to sell apartments online, which eventually left main constructors and building companies with the same credit ratings, and support measures for mortgages implying lower interest rates brought sales to a high level. Covid-19 could have negatively affected sales, but the state subsidized mortgage interest rates so that banks could provide them at reduced rates, and this helped the industry and banks maintain the level of mortgages and long money.

3. Results

The REPO instrument was a very valuable source of eliminating liquidity disbalance. In 2020, the banking sector was handling the situation with its own liquidity surplus, maintaining access to clients’ assets rather than investing them to obtain marginal profits, and as a result, the volume of REPO transactions was significantly lower than in the 2012–2015 crisis, which showed that Russian banks currently had enough liquidity. But the situation is changing in 2021.

As for indirect measures, such as support for the public, SMEs and corporates, we can conclude that the banking industry compensates for its returns via subsidies for lower interest rates. These indirect measures are essential to prevent the economy from falling, but at the same time they will lead to a long-term recovery period.

Now all sectors of the economy share the economic downturn, and the rise of the economy will be gradual but slow. Measures of support help all industries remain safe and credible.

So far, Russian support measures have been valuable for banks and the corporates that have indirectly influenced the banking sector. Subsidized mortgages did not allow the banking sector to significantly reduce the number of operations. At the end of March 2020, the Bank of Russia stopped bank checks due to COVID-19 and continued them from July 1. Thus, already on July 15, the Bank of Russia revoked the 5th license in 2020
from the People’s Bank of the Republic of Tyva. This was the first bank to lose its license after COVID-19. The main reason was that the bank had a small loan portfolio, which had 40% of bad debts. A significant share of the bank’s assets (over 80%) consisted of real estate objects, including unused in its core activity. The bank’s activity has been unprofitable for more than five years, which proved the inefficiency of the business model of the credit institution and resulted in the revocation of the license. Another 10 banks may lose their licenses as a result of the crisis and the reduction of the banking industry. The People’s Bank of the Republic of Tyva took the 416th place among other banks in Russia.

The current crisis has shown that the main risk concerns small banks outside the top hundred, banks specializing in lending to SMEs and individuals and having insufficient capital reserves. It is expected that during the current 5 years many small banks will leave the market and the concentration of the banking sector will increase owing to the big players.

This means that the government support of banks is insufficient for small and medium-sized banks that mainly operate on the basis of the business model of commercial credits to public and legal bodies. This model is too risky in the current crisis and not subsidized by the state support. As soon as small banks report, their financial situation with bad debts will be obvious, and we expect that such banks will become the objects of investigations by the Bank of Russia, which usually lead to the revocation of licenses. Large and strong systemic banks will retain their competitive advantages, while weak banks will become weaker.

State support measures in the form of subsidized interest rates for mortgages help businesses in large banks that deserve the trust of clients, while the rest of the population, who cannot afford mortgages in large reliable banks, turns to smaller credit organizations, which in crisis time leads to an increase in the number of bad debts as the unemployment rate rises.

The measures of state support applies only to large banks giving them confidence that there will also be customers tomorrow, while small and medium-sized banks have to sacrifice their marginal profits in order to leave the assets of legal bodies for liquidity purposes and follow the requirement and regulations. Large banks have liquidity thanks to state support, while small banks go bust or lose profit — this is the expected scenario.

4. Discussion

What can be changed in the government support measures to benefit not only large banks but also to redistribute support to medium and small players? The answer to this question, on the one hand, depends on the uncertainty about the duration of the pandemic and its impact on the global economy. When the pandemic ends, the economy will recover and banks will be able to restore their activity in line with economic growth.

---

If the pandemic does not end in the next 2–3 years the current state aid to the banks and the population will lead to the bankruptcy of small and medium banks and their life cycle will depend on how much these banks have managed to save in terms of capital.

The increase of volume of bad debts in the banking industry amounted to 20% y-o-y by January 1, 2020, which proves that the banking sphere had a very high risk before COVID-19. By April 1, 2020, the increase of volume of bad debts for 3 months was +4% and by August 1, it was +14% from January 1, 2020 (Figure 4). Now there is a positive upward trend in the growth of bad debts in the banking sector, which is also confirmed by an increase in the volume of bad debts in the total amount of credits.

The increase in the volume of bad debts in the entire amount of credits is due to the weakening of requirements for bank portfolios during the COVID-19 period, but as soon as the measures of support stop and banks have to face real situations with portfolio revaluation and bad debts provisions, the situation may become worse.

Elvira Nabiulina, head of the Bank of Russia, said that the economy had a substantial buffer to counteract the pandemic, but she thought that not all measures had yet been taken to maintain policy space in case the pandemic had a longer duration. Therefore, the Bank of Russia has not yet used all the ammunition at once and is ready for potential future shocks. “As a sizable permanent loss of potential GDP is inevitable, but it is hard to judge with confidence how large that could be in the long-run. Moreover, sizable structural shifts in the composition of economic activities, and hence employment, are also almost predetermined.”

Most likely, a shock for small banks is inevitable. If we talk about captive banks that service production companies or factories in terms of giving credits to employees of these companies, then we can say that such banks will survive.

Small banks that are working on business models of commercial loans or car loans for the public or SMEs are likely to faced very big difficulties in 2020–2021, as the state support measures simply went against them — they could not charge clients if they did not pay on loans, the margins were low, clients left and created deposits in large reliable banks. Nowadays, the shrinking of the banking sector is an inevitable consequence of the economic slump.

**Conclusion**

Russia’s banking industry suffered in 2020–2021 due to the coronavirus lockdowns and the country’s economy is expected to gradually shrink. After the government stops supporting to the public and businesses, banks will be able to see the results when the bad debts in the banking sector increases what may affect small and medium banks.

Large banks receive sufficient state support and REPO auctions should support them if the situation becomes worse. To date, REPOs have not been used to the same extent as in the 2014–2015 crisis.

---

The increase in the volume of bad debts in the banking industry amounted to 20% y-o-y by January 1, 2020, which proves that the banking sphere had a very high risk before COVID-19. By April 1, 2020, the increase in the volume of bad debts for 3 months was +4% and by August 1, it was +14% from January 1, 2020 (Figure 4). The trend is positive for the increase in the volume of bad debts in the banking sector, which is also confirmed by an increase in the volume of bad debts in the total amount of credits from 5.5% on January 1 to 5.7% on August 1 (see Figure 5).

**Source:** https://www.cbr.ru/statistics/macro_itm/dkfs/

**Figure 4.** Bad debts in the banking sector of credit assets (billion rubles)

The increasing volume of bad debts in the entire amount of credits is due to the weakening of requirements for bank portfolios during the COVID-19 period, but as soon as the measures of support stop and banks have to face real situations with portfolio revaluation and bad debts provisions, the situation may become worse by the end of the year.

**Source:** https://www.cbr.ru/statistics/macro_itm/dkfs/

**Figure 5.** The volume of bad debts in the total amount of credits in the banking sector in 2019–2020 (%)
Measures of government support proved to be very helpful for SMEs and people with loans who received credit “holidays,” for construction companies and large banks that managed to capitalize on the boom in mortgage which was incentivized by subsidizing the interest rate.

Small and medium-sized banks could get the support of REPO auctions to provide liquidity, but currently the demand for this instrument is low as banks rely on their own capital buffer.

Only one bank lost its license due to COVID-19 with low capital adequacy and high bad debts which turned out to be an unprofitable business model. How many banks will face the same result in 2021–2022? It’s just a matter of time before we get an answer to this question. Experts predict that, most likely, very soon we will see the revocation of banking licenses from 15–30 banks.

Our proposal on measures to support small and medium-sized banks will be to prevent the death of business and consumption as small and medium-sized banks traditionally work with SMEs and the bond between them is very strong. As long as SMEs survive, small and medium-sized banks will be alive, but what business model banks will choose during the crisis — it is another story. The orientation should now be reset from profit to following bank requirements.

Meanwhile, the Bank of Russia may temporarily soften its approach to bank risk management and continue support measures. Subsidized mortgages help construction companies continue to conduct their business in the regions and prevent local banks from defaulting. Recommendations on measures to support the banking sector should include the following:

*From the regulator’s side:*
1. Access to immediate liquidity, which is already provided by the Bank of Russia. During banking crises, liquidity runs out. In this case, the central bank either funds for a short time, or does not give anything at all. In the crisis of 2020–2021, there are good chances for banking liquidity through REPOS.

*From banks’ side, it is expected that banks should pay attention to:*
2. Bad debts decrease and enhanced risk management, which implies fewer loans to questionable business activities.
3. Revision of prices for the main products in the bank’s portfolio, changes in interest rates and negotiations with the central bank on the revision of reserve requirement rates — this allows to increase the amount of cash and strengthen the bank’s liquidity.
4. Restructuring of doubtful debts and revision of the credit portfolio.

**References**


Yannis Katsoulacos, Vasiliki Bageri

VTB BANK IS THE GENERAL SPONSOR OF THE WORLD FIRST SCIENTIFIC JOURNAL IN THE FIELD OF THE BRICS COUNTRIES ECONOMY
Author’s guidelines

Articles submitted to the journal should not have been published before in their current or substantially similar form, or be under consideration for publication with another journal.

The article should have a scientific novelty, relevance of the problem, clarity of presentation, and be of interest to a wide audience. Before submitting the author should be familiar with the standards of publishing ethics.

Articles in English only are eligible for submission. Authors are recommended to have their manuscripts edited by a native English speaker or professional English language editor before submission.

The journal does not accept submissions not meeting the content and layout requirements (see https://www.brics-econ.org/guidelines/).