Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia

THE GLOBAL SOUTH AIR TRANSPORT BELT: A CATALYST FOR SUSTAINABLE TOURISM AND ECONOMIC GROWTH

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Dissertação de Mestrado apresentado ao Programa de Engenharia de Engenharia de Transportes, COPPE, da Universidade Federal do Rio de Janeiro, como parte dos requisitos necessários à obtenção do título de Mestre em Engenharia de Transportes.

Orientador: Elton Fernandes

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O CINTURÃO DE TRANSPORTE AÉREO DO SUL GLOBAL: UM CATALISADOR PARA O TURISMO SUSTENTÁVEL E PARA O CRESCIMENTO ECONÔMICO

Bruno Garcia Franciscone

Fevereiro/2024

Orientador: Elton Fernandes

Departamento: Engenharia de Transportes

Este trabalho explora os aspectos técnicos da ideia de um Cinturão de Transporte Aéreo do Sul Global, para promover o desenvolvimento e o crescimento econômico, com ênfase especial nos países em desenvolvimento. O transporte aéreo vem sendo reconhecido como um poderoso catalisador para o comércio mundial, impulsionando o turismo, promovendo troca de experiências entre as pessoas e incrementando a eficiência da cadeia de suprimentos. Entretanto, uma evidente disparidade entre os sistemas de transporte aéreo dos países no Norte Global e no Sul Global persiste, explicitada pelo número de aeroportos, pela rede de rotas e pelos volumes totais de voo. Adicionalmente, o Esquema Redução de Carbono para a Aviação Internacional (CORSIA) impõe um obstáculo ao progresso do transporte aéreo nos países em desenvolvimento. CORSIA, uma medida baseada em mercado com a finalidade de estabilizar as emissões da aviação civil internacional a partir de 2020, tem o potencial de estagnar o desenvolvimento atual das conexões de rotas, impedindo potencialmente as perspectivas de crescimento das ligações aéreas diretas sul-sul. Como alternativa, esse trabalho propõe a adoção de medidas operacionais explicitadas no Plano Global de Navegação Aérea da Organização de Aviação Civil Internacional, conjuntamente com a utilização de combustíveis sustentáveis a implementação de avanços tecnológicos. Tal abordagem está alinhada com os objetivos de desenvolvimento sustentável, abrangendo uma visão mais ampla para o progresso da sociedade e cooperação sul-sul. Neste contexto, esse trabalho destaca o potencial para o desenvolvimento sustentável pela promoção e expansão da infraestrutura de transporte aéreo em países em desenvolvimento, com ênfase particular nas nações dos BRICS. Por meio da criação de um cinturão de transporte aéreo coeso no Sul Global, pode-se facilitar o crescimento do turismo e promover o crescimento econômico nas nações participantes. Tal iniciativa busca capitalizar os potenciais únicos dos países do Sul Global, oferecendo um caminho sustentável em direção ao crescimento econômico inclusivo e ao progresso social.

Abstract of Dissertation presented to COPPE/UFRJ as a partial fulfillment of the requirements for the degree of Master of Science (M.Sc.)

THE GLOBAL SOUTH AIR TRANSPORT BELT: A CATALYST FOR SUSTAINABLE TOURISM AND ECONOMIC GROWTH

Bruno Garcia Franciscone

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Advisor: Elton Fernandes

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This work explores the technical aspects of a Global South Air Transport Belt idea to enhance development and economic growth, particularly emphasizing developing countries. Air transport is a powerful catalyst for facilitating world trade, boosting tourism, promoting people-to-people exchange, and enhancing supply chain efficiency. Nevertheless, a pronounced disparity in air transport systems between countries in the Global North and Global South persists, evident in the varying number of airports, route networks, and total flight volumes. Additionally, the Carbon Offset Scheme for International Aviation (CORSIA) poses an obstacle to the progress of air transport in developing nations. CORSIA, a market-based measure aiming to stabilize international civil aviation emissions from 2020, can stagnate the actual international developing countries' network connections, potentially impeding the growth prospects of the south-south direct air links. As an alternative, this work proposes adopting operational measures outlined in the Global Air Navigation Plan of the International Civil Aviation Organization, alongside using sustainable fuels and implementing technological advancements. Such an approach aligns with the sustainable development objectives of developing nations, encompassing a broader vision for societal progress and south-south cooperation. In this context, the work highlights the potential for sustainable development by promoting the expansion of air transport infrastructure in developing countries, with particular emphasis on BRICS nations. By creating a cohesive air transport belt in the Global South, this strategy could facilitate tourism growth and foster economic development across the participating nations. Such an initiative seeks to capitalize on the unique potential of the Global South countries, offering a sustainable pathway toward inclusive economic growth and social progress.

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SUMARY

1 INTRODUCTION

The research, as consolidated in this dissertation, is anchored in three core papers submitted for publication in scientific journals and/or presented at international conferences. These are:

i. FRANCISCONE, Bruno G..; Fernandes, Elton; **Operational Improvements to Reduce Air Traffic Emissions in Developing Countries.** World Conference on Transport Research – WCRT 2023, Montreal, Canada. Accepted for publishing in Transport Research Procedia, Elsevier.

ii. FRANCISCONE, Bruno G.; Fernandes, Elton. **Operational Improvements and Sustainable Air Transport Development in The Global South**. In: The 2nd BRICS Research Conference, 2023, Kota. BRICS Research Conference, University of Kota, India, 2023. Accepted for publishing as book chapter.

iii. FRANCISCONE, Bruno G.; Fernandes, Elton; Zou, Xialong. **The Global South Air Transport Belt: A Catalyst for Sustainable Tourism and Economic Growth.** Submitted to Journal of Air Transport Management.

In this introductory chapter to the dissertation, in the first section, the development of international air transport is briefly described, from the use of military planes adapted to transport passengers commercially after the end of the First World War through the establishment of conventions and treaties that regulated and boosted international air transport activity, until the dizzying expansion of the international passenger transport industry in the 1980s. The following section presents the correlation between the degree of development of the air transport industry and economic growth due to several factors, including the intensification of international tourism activities. It also highlights that connectivity within the Global North and the Global South towards the Global North is high, influencing the benefits developed countries obtain from international tourism activities. Finally, the section indicates the need for investment in air transport infrastructure in developing countries, among other necessary actions, to boost international tourism activities within the Global South to promote economic growth.

The third section presents BRICS as a conglomerate of countries representing the Global South. It points out their enormous purchasing power and the possibility of significantly benefiting from inbound tourism growth supported by the other block's countries. In the fourth section, based on data from the World Bank, a comparison is made between the number of international airports per million inhabitants of the G7 and BRICS countries, the expenses and revenues from international tourism activity, and the number of seats on flights from BRICS countries to the G7 countries and between BRICS countries to highlight the vast differences between the Global North and Global South air transport infrastructure and connectivity. Finally, in the fifth section, the general and specific objectives of this research are presented, as well as the delimitation of the object of study and the methodologies used.

1.1 The development of the International Passengers Air Transport

After the First World War, the possibility of transporting passengers and cargo by air surged. At that time, air transport activity was still very rudimentary, and pilots followed air traffic rules that differed according to the country in which they were flying, causing great confusion, especially in Europe, where aircraft crossed several countries during their displacements. In addition, flying was extremely expensive, dangerous, and uncomfortable for passengers. Therefore, several technical, economic, and political challenges raised doubts about the possibility of developing international air transport. Shortly after, transporting passengers and cargo with adapted military aircraft became a reality. As there was still no air traffic control system, the pilots organized themselves by applying archaic rules adapted from road traffic. While the number of aircraft flying was small and flight paths short, there was still no need for an air traffic control system. (Gilbert, 1973).

The intensification of air transport activity depended on international regulation. The Allied Powers took advantage of the favorable moment of the treaties arising from the First World War to regulate the air navigation regime. The Paris Peace Conference in 1919, with representatives of several countries, as seen in Figure 1, addressed several aviation-related issues and authorized the creation of an Aeronautical Commission composed of several countries. This commission produced the Paris Convention, consisting of 43 articles on civil aviation's technical, operational, and organizational aspects. The most relevant achievement of this convention was the creation of an International Air Navigation Commission. However, despite the commission's efforts to standardize the registration, airworthiness, and air navigation of aircraft and to create a certification for pilots and other crew members, it did not offer a uniform and safe system for international civil aviation due to the unstable political context after World War I (Dobson, 2017).

Figure 1 - Paris Peace Conference. Source: ICAO.

The first decade of commercial aviation did not see significant advances in aircraft design, and the growth of international air transport activities only started to be observed from 1920 onwards. Passenger transport, however, still represented a tiny portion of this market. They were already operating multi-engine aircraft, but their primary purpose was transporting cargo. At the time, the Ford Trimotor aircraft innovatively had a comfortable cabin exclusively for passenger transport (Filburn, 2020). In the interwar period, three main challenges menaced the development of civil aviation. The first was technological, producing safe passenger transport planes capable of navigating oceans and continents. The second challenge was economic and referred to the effort to make airlines financially sustainable. Finally, the political challenge consisted of reconciling interests and delimiting the decision-making level of the various civil aviation stakeholders. Facing these challenges for developing civil aviation worldwide did not occur uniformly and at the same time (Dobson, 2017).

Europe developed the air transport industry before any other part of the world with the help of solid government subsidies. The world's first airline, Koninklijke Luchtvaart Maatschappij (KLM), was founded in 1919. The following year, it transported the first passengers from London to Amsterdam using the Fokker II aircraft, as shown in Figure 2. However, from 1925 onwards, the United States began to develop more quickly in the air transport industry, and by 1930, it had already transported more passengers than all regions of the world combined (Cook, 2007).

Figure 2 - Aircraft from the first airline. Source: KLM.

Because of the growing demand for passenger air transport, several aircraft designers and manufacturers have emerged worldwide, especially in the United States. At that time, new models inspired the development of modern airline aircraft. Among these models, the Boeing 247 and the DC-3 stand out, surpassing the Boeing 247 in passenger transport capacity (21 seats). Shortly before the Second World War, Boeing launched the model 307 Stratoliner on the market, with a pressurized fuselage capable of carrying 33 passengers. In 1939, due to this enormous development, the American company PanAM already had a monopoly on oceanic routes (Filburn, 2020).

Bilateralism between the United States and the United Kingdom prevailed interwar. These nations negotiated with each other on how to carry out transatlantic services. While the United States had a more significant number of aircraft and a very robust route network, the United Kingdom controlled most of the airfields and strategic supply points essential for transatlantic routes. The agreement between the Americans and the British aimed to guarantee the exclusivity of operation on the transatlantic routes to the companies PanAm and Imperial Airways. This exclusivity consisted of excluding all other airlines from other countries by denying the right to land for refueling on transatlantic routes, especially in Newfoundland and Bermuda (Dobson, 2017).

Several passenger and cargo transport routes emerged in this World War context. However, there were still several obstacles of a technical and political nature and the lack of support structure for air navigation, which prevented a robust expansion of these routes. The US government then invited 55 States to participate in the Civil Aviation Conference in Chicago in 1944. Altogether, 54 of the 55 invited countries sent delegations, and 52 signed the International Civil Aviation Convention, known as the Chicago Convention. This conference represented an attempt by the US government to “loosen” the regulation that, in its view, restricted the aeronautical industry in the interwar period (ICAO, 2020). In 1946, a more orderly and structured system emerged with the Treaty of Bermuda, with rules defined by the United States. Despite its flaws and limitations, this treaty contributed to the expansion of international civil aviation between the 1940s and 1970s. This treaty represented a commitment assumed by nations with antagonistic views and conceived a regime of equal opportunities for competition, mutual approval of tariffs, and establishing capacities based on the real needs of populations (Singh, 2019).

Aircraft continued to evolve. In the 1950s, the American company Lockheed developed the Constellation aircraft, which could carry up to 100 passengers on a transatlantic flight. The Douglas company produced the DC-6 model, capable of carrying 100 passengers at a cruising speed of 300 mph. The development of these two aircraft marked the end of the era of piston-engine aircraft. The age of jet aircraft began. The British were pioneers in the jet engine aircraft market. However, they only managed to dominate this market briefly since the Comet aircraft they developed had several flaws in its design, causing accidents between 1953 and 1954. After that, the American company Boeing entered the commercial jet market with the 707 model, capable of transporting 181 passengers and developing a cruising speed of 600 mph. Due to the success of this model and others developed later by the company, there was a dizzying increase in the number of flights worldwide, and air traffic grew by 345% between 1949 and 1960 (Filburn, 2020).

Civil aviation continued to expand throughout the 1950s, 1960s, and 1970s. The number of routes increased yearly, and aircraft became larger and faster. Because of this evolution, new technologies for air traffic management activity emerged to maintain the efficient flow of aircraft and operational safety at an acceptable level (Wickens et al., 1997). Regulation of civil aviation remained very intense despite technological advances and the possibility of growth in the air transport sector worldwide. In Europe, there were many subsidies and government aid to airlines. These subsidies made the market commercially inefficient and non-competitive and allowed the formation of cartels that did not serve the public interest (Dobson, 2017).

Until 1984, little changed in the European air transport system scenario, but strong influences of market forces from the Americans propagated ideas that began to gain strength and promote change worldwide, even at different paces due to economic inequalities (Dobson, 2017). The European aviation market, dominated by bilateral agreements, gradually gave in to the American liberal wave, and little by little, the countries of the European Union got rid of the consolidated and traditional concept of sovereignty. New companies emerged, the network of international routes grew, and the privatization of airports began. (Singh, 2019).

1.2 The Air transport activity and its impacts on economic development

Studies indicate a bidirectional correlation between the development of air transport and economic growth, especially in developing countries. The development of air transport brings several associated benefits, such as facilitating international trade, attracting investment from foreign countries, and boosting tourism. Additionally, there is a direct contribution to economic growth through the generation of jobs and income in activities related to the construction of airport infrastructure and, later, during the operations of these airports (Pisa, 2010). The spillover effects also occur and consist of local advantages derived from this development of air transport. These advantages are related to increased employability in the metropolitan regions where this development occurs (Zhang; Graham, 2020).

ICAO recognizes that developing and expanding air transport is crucial for economic growth and social inclusion (Hasan et al., 2021). Regulators and politicians must ensure that regulating the air transport industry meets the interests of society and local communities (Marazzo, Scherrer; Fernandes, 2010). The development of air transport is also a catalyst for tourism. However, other factors to consider are equally important, such as economic conditions, logistical costs, trade regulations, and the capacity and performance of the supply chain, among others. In addition, the socioeconomic profile of a passenger, the distance to the final destination, the available modes of transport, and the price of services influence a passenger's decision to choose a particular destination (Pisa, 2018).

Connectivity is an indicator associated with the economic development of countries. It consists of the concentration of the route network and its ability to link origins and destinations and transport passengers between them. Therefore, connectivity is associated with creating more expressive economic benefits for Tourism and several other activities (Dimitrios; Maria, 2018). There are currently many routes with an intense flow of air traffic from the Global South toward the Global North, consisting of robust connectivity. This reality reproduces historical ties of colonialism and migration patterns established in the past (Njoya; Knowles, 2020). However, there needs to be a higher connection between the Global

South countries. When analyzing Figure 3, it is possible to see that few people are moving between these countries.

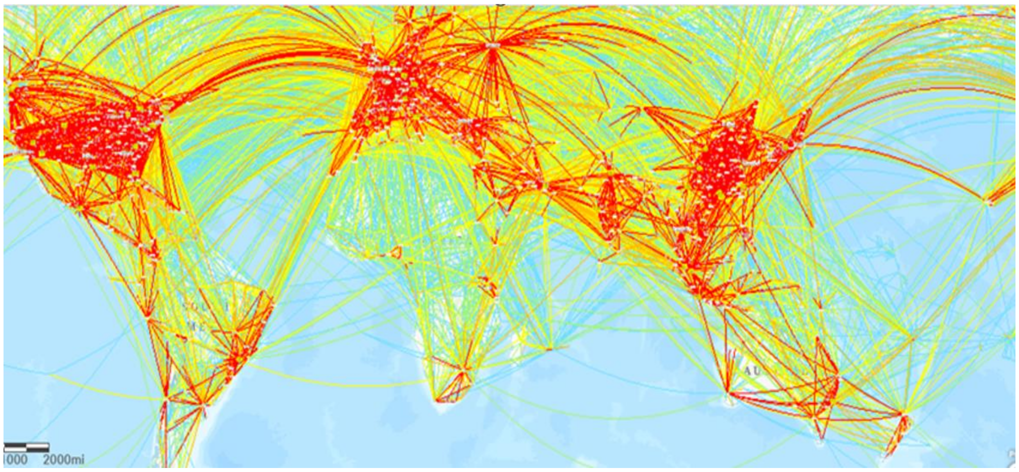

Figure 3 - Route Network Concentration in the World. Source: ICAO.

A significant number of flight arrivals in a given location impacts its economic growth and the expenses tourists make in these countries. Among the potential factors that can prevent the association between economic growth and the number of flights arriving at airports in a given country, one can list political instability, anti-terrorist wars, direct and indirect regulatory barriers, inadequate infrastructure, underdeveloped human capital, opaque business policy, neglect of export-oriented sectors, poor situations related to law and order, among others (Usmani; Akram, Praveen 2021).

Tourism is like an export activity and an essential foreign exchange source from low capital investments, generating a positive balance of payments and revenue rates for guest nations. Export activities boost the demand by bringing the consumer closer to several other producers in a given country (Usmani, Akram; Praveen, 2021). Additionally, tourists spend resources on purchasing goods and services that generate spill-over benefits in various sectors of the economy, generating seasonal and permanent jobs for unskilled labor. Studies prove that tourism promotes economic growth in countries from South America, Asia, and Africa (Pisa, 2018).

Generally, countries in the Global South have poor air transport infrastructure, negatively impacting their economic growth. However, the recent expansion of the air transport sector provides an essential opportunity for the structural transformation of the economy of countries in this region (Njoya; Knowles, 2020). Investment in air transport infrastructure in developing countries does not guarantee economic growth *per se*, even though it increases accessibility. The factors that may contribute to the lack of economic growth despite infrastructure investment are underutilization due to the need for adequate auxiliary and support services. Other relevant factors are the countries' geographic, political, governance, and technological development characteristics. It is essential to highlight that demand for air transport is driven by social and economic factors and not just by the price of services. Therefore, increasing Gross Domestic Product (GDP) and changing society's consumption patterns can increase this demand (Park, Seo; Ha, 2019).

It is essential to mention that the bigger the debt of developing countries, the less these countries invest in air transport infrastructure since there is a reduction in public capital investments, and with that occurs the cancellation or postponement of projects. Additionally, as many areas in these countries, such as education and health, need more infrastructure, intense competition exists for investments. In addition, on several occasions, the money planned for investment in infrastructure is used for different demands considered more urgent, generating a vicious circle that compromises long-term economic growth (Park; Seo; Ha, 2019).

Despite the infrastructure problems, commercial aviation has become the fastest-growing industry in the Global South. This growth even surpassed the world average for growth in the sector. However, even considering this intense growth, there is a “gap” between the development of air transport in the Global North and the Global South. This “gap” can be evidenced by the analysis of existing routes and traffic flows, which show that traffic flows between regions of the Global South are considerably more limited than traffic flows between regions of the Global North and the Global South, as mentioned before (Njoya, Knowles, 2020).

There are significant signs that the Global South countries will greatly influence world economic relations shortly (Quah, 2011). Considering this fact, cooperation between countries in the region is essential to promote international tourism activities to enable economic development and allow these countries to enjoy their prosperity. Tourism is vital in reducing poverty in developing countries (Hemana, 2013). Many developing countries are choosing or being encouraged to develop tourism instead of other, more traditional industries such as agriculture and manufacturing.

1.3 The importance of international tourism activities for the BRICS

The BRICS conglomeration is an excellent example of international economic integration, making up part of the Global South. The BRICS have the majority of the world's population and natural resources. Promoting international tourism in these nations can favor their economic growth and development. A study on the impact of Tourism on the economic development of the BRICS validated the hypothesis of induction of economic growth in the long term. It is noteworthy that an adequate development of human capital generates more significant impacts on real economic growth (Misha; Rout; Sahoo, 2021).

The importance of inbound tourism activities has grown intensely in BRICS countries due to the evidence of their contribution to long-term economic development. For these countries, a 1% increase in per capita tourism receipts results in a per capita GDP growth of 0.31% in the long term (Rasool et al.., 2021). Tourism is widely associated with the 1st goal of the United Nations Sustainable Development Goals, which advocates promoting tourism to reduce poverty (Garidzirai; Matiza, 2020). Because of this, these countries should encourage the growth of their tourism industries by prioritizing inbound tourism and developing adequate infrastructure to attract tourists. This infrastructure consists of adequate transport, attractive destinations, viable hotels, and an acceptable level of security. (Rasool; Maqbool; Tarique. 2021). These countries seek to increase their soft power to improve their competitive image in the international tourism market (Garidzirai; Matiza, 2020).

In 2018, China had 140 million tourists, making the highest tourist expenditure in the world. This number will reach 300 million by 2027. Five BRICS countries entered 2018 in the ranking of the 20 countries with the highest contribution to the GDP generated by international tourism activities in their economies. A study based on a dataset of BRICS countries, with data from 1995 to 2017, showed that revenues from international tourism activities, arising from travel and product exports, had a positive impact on poverty reduction in these countries in the long term, while revenues from hospitality and accommodation had a positive impact on poverty reduction in the short term (Garidzirai; Matiza, 2020).

Despite the severity of the COVID-19 pandemic, the total contribution of tourism activities to GDP in the BRICS nations remained significant in 2020. In 2019, the total contribution of these activities to job creation was quite expressive, represented by percentages of 8.2% in Brazil, 5.6% in Russia, 8.8% in India, 10.6% in China, and 8.9% in South Africa. These percentages varied little during the COVID-19 pandemic and demonstrate the magnitude with which tourism activities contribute to economic growth and development (Misha; Rout; Sahoo, 2021).

There is an enormous potential for inbound/outbound tourism activities within the BRICS. The purchasing power of the bloc's countries is enormous. In the longer term, tourism can significantly impact domestic consumption and alleviate poverty. This process intensifies if these countries promote tourism activities inside the block. For this to be viable, it is necessary to establish a preferential visa regime, adequately train their human resources, and favor technology transfer. It is also necessary to increase investments in the sector and develop strategies that allow local communities to hold the resources to explore tourism (Garidzirai; Matiza, 2020).

1.4 Comparative features between BRICS and G7 countries

There is a clear difference in the air transport infrastructures of the BRICS countries and the G7 countries. However, it is essential to emphasize that the provision of infrastructure alone, as already mentioned, may not guarantee economic growth. Due to this, it is also vital to analyze international tourism activities and other types of activities that use that infrastructure. In the case of international tourism activities, it is necessary to analyze the revenues and expenses and the number of seats available on flights departing and arriving from countries to understand the displacement patterns at international airports.

The World Bank database contains the number of international airports in the G7 countries and the nations that comprise the BRICS. Dividing the number of these airports in the G7 and BRICS countries by the population in each country results in an indicator shown in Figure 4. The graph in the figure shows that, except for Russia, all other BRICS countries have fewer international airports per million inhabitants than the G7 countries.

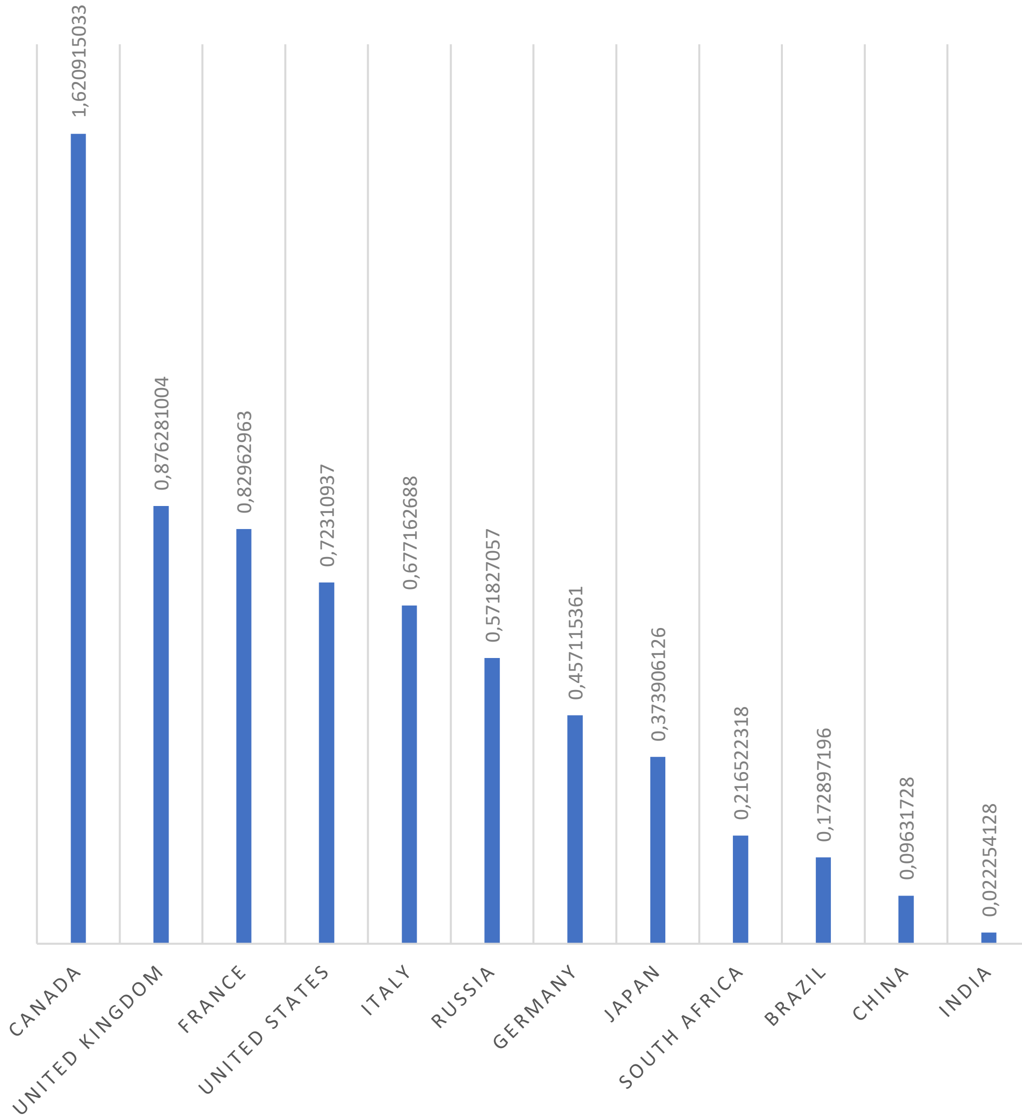

Figure 4 - Number of International Airports per million people. Source: World Bank

Analyzing now the amounts spent and received concerning international tourism activities by the G7 and BRICS countries shown in Figures 5 and 6, it is clear that the G7 countries were responsible for 56% of expenditures on international tourism and obtained around 84% of total revenue from the same activity in 2018 (considering only the G7 and BRICS countries total amounts).

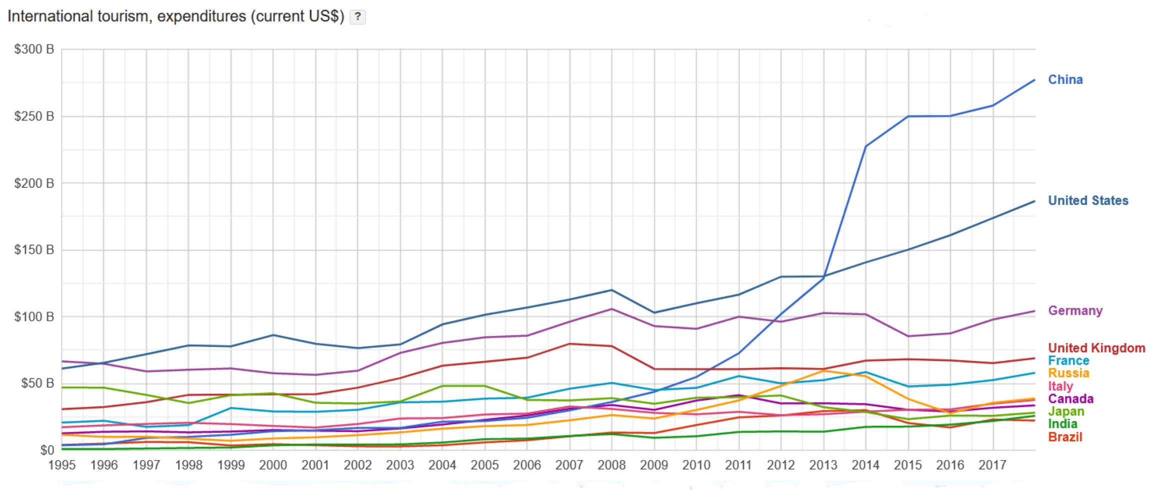

Figure 5 - Expenditures on International Tourism. G7 and BRICS nations. Source: World Bank.

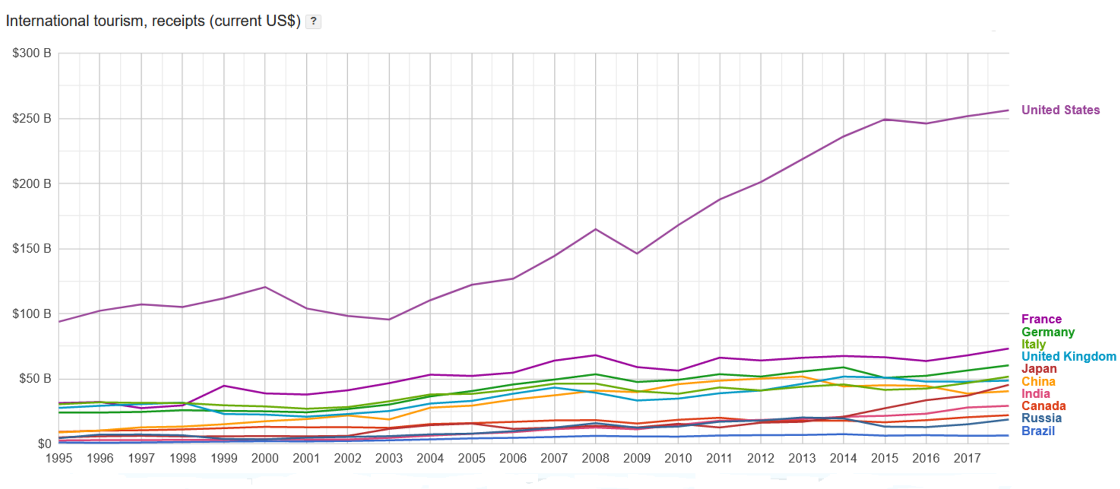

Figure 6 - Receipts from International Tourism. G7 and BRICS nations. Source: World Bank.

Now, considering the World Bank data regarding the number of seats available in 2019 on direct flights between BRICS and G7 countries, it is clear that the number of seats on flights from BRICS countries to G7 countries corresponded to 68,049,553, about 89% of the total seats. The seats available on flights between BRICS countries were 7,693,155, only 11% of the total seats, as seen in Figure 7.

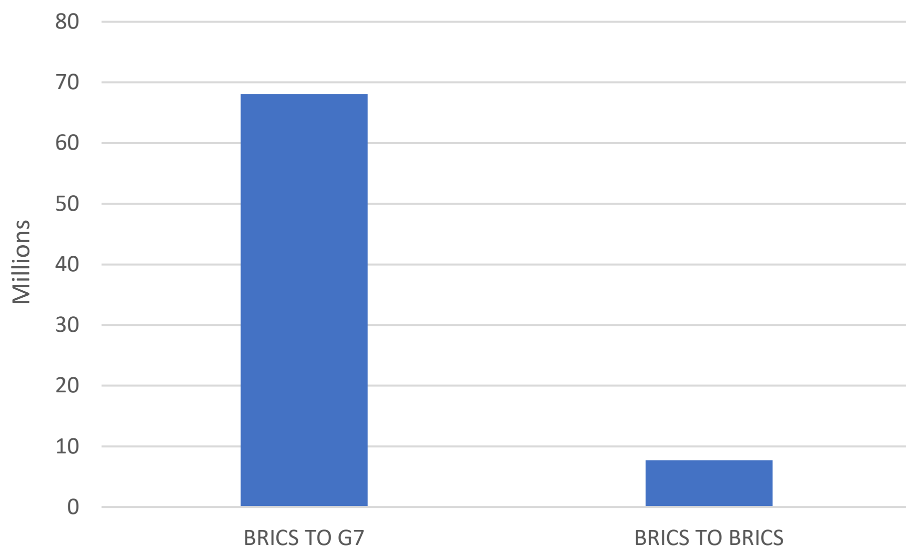

Figure 7 - Total number of seats available in 2019 for flights between G7 and BRICS nations. Source: World Bank

1.5 Contributions, general and specific objectives, methodology and limitations of the study

In recent decades, there have been several studies regarding the impacts of air transport on economic growth in countries of the Global North. However, more research is necessary on the development of air transport in the Global South countries and its impact on economic growth (Njoya; Knowles, 2020). BRICS nations represent nations of the Global South and constitute an essential multilateral cooperative that brings together the world's leading emerging economies. These countries account for almost half of the world's population, generate a quarter of global GDP, and have a 16% share of international trade. In addition, considering only China and India, in 2022, they accounted for about 15% of world consumption, and the expectation is that by 2050, they could account for up to half of world consumption (Kharas, 2010). The development of air transport in BRICS nations has the potential to favor the growth of the tourism industry. However, cultural approximation actions are necessary between these countries' populations to establish a more robust route structure to interconnect these countries.

This research aims to analyze the technical feasibility of creating an air belt of routes to interconnect the BRICS countries and allocating commercial passenger transport flights to promote tourism activities between them to favor their economic development sustainably. In order to achieve this general objective, this study will include the following specific objectives:

a) analyze the potential of the international tourism market of the BRICS and point out the importance of the activity for the economy of these countries;

b) analyze potential barriers to the growth of international air transport activities and, consequently, the economic growth of the BRICS countries with adherence to CORSIA and point out alternative means for the sustainable growth of air transport activities in these countries; and

c) verify the viability of structuring a network of routes between the main airports of the BRICS countries and the possibility of allocating flights in this network.

As a delimitation of the subject of study, the technical feasibility analysis of creating routes and allocating commercial flights between places with the potential to attract international tourism activities was defined only for BRICS countries and not for all countries of the Global South.

Regarding the methodologies used in this work, it is important to evidence the use of data from 2019 made available by the World Bank regarding air transport infrastructure, expenses and revenues arising from international tourism activities, and the number of seats on flights from BRICS countries and the G7. These data highlighted the differences in the air transport systems of the blocs representing the Global North and the Global South. The study also used data made available by ICAO, referring to the connectivity of the BRICS countries, to obtain an overview of the current route network and the number of flights from these countries to other countries.

To estimate the reduction in CO2 emissions obtained through the implementation of operational measures at Brazilian airports, the methodology established in ICAO Doc 9988, "Guidance on the Development of States' Action Plan on CO_2 Emissions Reduction Activities," was used. This methodology consists of applying empirically established formulas that differ for each type of operational measure implemented at airports that provide estimates of CO_2 emission reductions based only on the number of movements at these airports and the type of aircraft operating there.

To analyze the feasibility of allocating direct flights between airports in the BRICS countries, the Flight Calculator software from Aviapages proposed a network of routes between these countries. This software is available on the unique platform developed by the company, which provides diverse solutions for business aviation stakeholders. From a few inputs, this software can determine the possibility of allocating flights between any two airports worldwide, considering the critical aircraft capable of operating at them.

The importance of this study lies in the fact that if it is feasible to create a Global South Belt and allocate flights that use this structure, it will become apparent the potential for intensifying international tourism activities among these developing nations and, consequently, promote a boost to their economic growth in a sustainable way.

2 OVERVIEW OF THE TOURISM MARKET IN THE BRICS COUNTRIES

This chapter presents an overview of the inbound tourism market in the BRICS countries and shows its evolution over the last few decades. It also highlights the importance of tourism activities for the economies of the BRICS countries and the public policies adopted by each country to strengthen it. The chapter also points out the strengths and flaws in the tourism market in each country.

2.1 The tourism market in Brazil

Although Brazil does not depend exclusively on tourism, this activity represents one of the most important economic and development sectors. Brazil is the largest country in South America and has a rich cultural and ecological diversity. However, the tourism sector needs more attention from public policymakers and the private sector. Until the early 1990s, tourism played a mediocre role in social and economic contributions to the country compared to other South American countries. Despite that, at the end of the 1990s, the number of tourists arriving in Brazil began to increase, and with that, the income from these activities also started to grow. This fact resulted from the economic reforms implemented in 1994, which paved the way for implementing tourism programs that started to boost the sector. Implementing the National Tourism Policy from 1996 to 1999 was essential for Brazil's new phase of tourism development. (Santana, 2000). The success of this policy made Brazil evolve in the sector and become the country in South America that receives the most international tourists, around 30% of the total (Sobral; Peci; Souza, 2007).

Even with the improvements in the sector, only some international tourists visit Brazil, considering the global scenario. In 2013, more than 40 countries received a more significant number of tourists than Brazil (Tavares, Leitão, 2016). Of the 100 million Chinese who traveled the world in 2014, only 60,000, that is, 0.06% of them, chose Brazil as their destination (Lima; Mainardes, Rodrigues, 2020). However, the country can potentially expand its presence in international tourism by developing its image (Santana, 2000).

Brazil is an exotic destination for foreigners in general. Its most striking positive characteristics are its ecological diversity, pleasant tropical climate, and friendly and welcoming population. Also noteworthy are Carnival, natural beauties, football, and music. However, foreign tourists also look at negative characteristics and social problems when choosing a destination to travel. Unfortunately, Brazil has high crime rates, environmental degradation, and high rates of hunger and poverty. In addition to the negative image generated by factors associated with poverty, crime, and environmental degradation, the lack of basic infrastructure and support for tourism activities contribute to the country's low demand for foreign tourists. The absence of support for tourism activities consists of poor information for tourists, traffic congestion, the unsatisfactory standard of airport facilities, the high cost of airline tickets, and the lack of roads and connection networks (Santana, 2000). Some surveys also point out that one of the main complaints of foreign tourists is the difficulty of the Brazilian population and Brazilian tourism agents in communicating in English (Tavares; Leitão, 2016). However, the image of Brazil does not consist of something fixed and immutable. It, therefore, has the potential to be improved so that the country can be more attractive and attract foreign investment (Mariutti, 2013).

The preferred destination in Brazil pointed out by international tourists is Rio de Janeiro, but other destinations, such as the Amazon and the Pantanal, attract more and more tourists. Other prominent cities regarding the number of tourists received are Florianópolis and São Paulo. Most of Brazil's tourism development has taken place in coastal areas. The beach represents the ideal holiday environment for domestic and international tourism markets. The Brazilian coast is experiencing unprecedented investment and transformation due to government policies. Although there is no precise data, there is an estimate that 90% of domestic holiday trips in the country are to the coastal area. However, this occupation of the coast is causing social and environmental impacts, and a new proposal for sustainable tourism must be applied to mitigate these obstacles (Santana, 2003). Since tourism represents a strategic sector for the development of Brazil, strategies must be adopted based on the application of public policies that mitigate this evidenced lack of support as well as the social and environmental impacts pointed out (Sobral et al., 2007).

The Competitiveness Report for Travel and Tourism 2013, provided by the World Economic Forum, showed Brazil in position 51 out of 140 countries. Considering the price competitiveness category, Brazil ranked 126th. In 2014, Brazil registered the arrival of 6,429,852 international tourists, most of them from South America. With the Aquarela Plan 2020, illustrated by Figure 8, Brazil established a matrix of strategic priorities to define the level of investments for promoting tourism in Brazil in several countries. The definition of the so-called Blue countries is the primary market due to their importance for international tourism, as well as their accessibility and interest in Brazil. These countries are Argentina, the United States, Chile, Portugal, and most European countries. The Green countries, conversely, are considered intermediaries between primary and secondary markets due to their current moderate volume of travel to Brazil and their interest in the country. These countries are Portugal, Uruguay, Paraguay, Colombia, Peru, and Ecuador. The countries defined as Yellow countries represent secondary markets due to their low volume of trips to Brazil, but which may become more interested in the country. These countries include Norway, Sweden, Finland, Japan, Mexico, and Canada. Finally, the so-called White countries represent the tertiary market due to their lower volume of trips to Brazil, which may offer future opportunities. These countries are Bolivia, Venezuela, China, Russia, India, and Turkey (Tavares, Leitão, 2016).

Figure 8 - The Aquarela Plan. Source: Tavares; Leitão, 2016.

Due to proximity, Brazil must invest in public policies that promote tourism in Latin American countries. Geographical distance harms tourism demands but shared borders, and languages have a positive effect. However, even if close neighbors generate travel volume, they generally do not spend large amounts of money and do not stay for long. Visitors from distant locations do the opposite. Even though all tourism authorities want tourists who stay for long periods and spend a lot, the size of the market is restricted (Tavares, Leitão, 2016).

2.2 The tourism market in Russia

As of 2014, the tourism business in Russia has changed dramatically due to the substantial depreciation of the ruble, the bankruptcy of several relevant tour operators and airlines, and restrictions on travel to destinations considered famous for Russians, such as Egypt and Turkey. This change resulted in externalities for outbound tourism. However, the domestic tourism market in the country changed its structure and grew until 2018, with the emergence of new destinations. The balance between arrivals and departures of tourists from Russia could have been more stable. Between 1994 and 2003, the number of arrivals exceeded the number of departures. After that, from 2004 to 2013, the number of departures surpassed the number of arrivals and reached a peak of 54 million in 2013 (Gudkov et al., 2018). In 2014, the picture changed again, and the number of arrivals started to grow while the number of departures started to fall. In 2015, only 36 million Russians traveled abroad.

The number of foreign tourists visiting Russia remained relatively stable from 2014 to 2017, with no significant upward or downward variations. As of 2017, domestic tourism in Russia has become more diverse, with new destinations such as Crimea, Kazan, Grozny, and Altari, among others (Gudkov et al., 2018). Most foreign tourists entering Russia come from China, Germany, the United States, Israel, South Korea, India, Belgium, and Switzerland (Sheresheva, 2018).

The majority of Russian tourists spend their holidays in Russia itself. Among Russians' favorite domestic destinations are cities in the Krasnodar region and Moscow, including Moscow, St. Petersburg, and Sochi. It is possible to observe significant and growing flows of tourists to Crimea, Caucasus, Kazan, Vladivostok, and other small Russian cities. Finally, the most popular destinations for Russians are Turkey, Egypt, Thailand, Greece, Spain, and the United Arab Emirates (Gudkov et al., 2018).

Russia is an opportune choice for many types of tourism. The country has cultural characteristics from both East and West. It has various historical sites, diverse climate zones, beautiful landscapes, magnificent cultural heritage, and a wealth of natural resources. The vast majority of Russian cities are small and have their own peculiarities and unique historical values , and therefore, they have potential attraction in the rural tourism market (Sheresheva, 2018). According to data from the Federal State Statistics Service, there are about 2742 museums, 649 theaters, and tens of thousands of cultural heritage sites in Russia. The country also has enormous potential for active tourism, with dozens of parks and forest reserves located in different climatic zones with a great diversity of landscapes, rivers, lakes, and mountains that favor ecotourism and adventure tourism. It should be explored sustainably, with particular attention to cultural integrity, community involvement in villages and small towns, and analysis of present and future social and environmental impacts (Sheressheva et al., 2020).

Russia ranked 45th out of 141 countries in tourism and hospitality, as described in the World Economic Forum Travel and Tourism Competitiveness Report 2015, moving up 13 places since the last report in 2013. The depreciation of the ruble value from 2008 onwards also helped in the practice of more competitive prices, which attracted more tourists (Andrades; Dimanche, 2017). In the 2017 report, Russia rose two more positions and became

43rd. However, when analyzing other specific indicators related to tourists, which consider road quality, the density of the land route network, the quality of tourism services, and the perception of safety, among others, the country's position drops significantly, placing the country much closer to the last place in the ranking. (World Economic Forum, 2017). What makes Russia ranked 43rd, therefore, is not its transport infrastructure or the quality of tourism services but the attractiveness of its cultural heritage (Sheresheva,2018).

The potential for inbound tourism still needs to be fully utilized. Western media spread the information that Russia is not a suitable country for tourists (Sheresheva; Kopiski, 2016). Additionally, to the unfavorable image, the precarious infrastructure, lack of training and education of the workforce, difficulty in processing visas for foreigners, and lack of resources for accommodation and recreation in almost all regions with the potential to attract tourists, especially in the small cities, contribute for the poor results of the inbound tourism in Russia (Andrades; Dimanche, 2017).

The Development of various types of tourism and new destinations, considering the geographical locations and climatic conditions of different regions of Russia and their differences in culture and financial resources, requires efforts by the state, business people, regional authorities, and local communities. In order to achieve the federal government's objective in the program "Development of Domestic Incoming Tourism in the Russian Federation (2019 – 2025)", it would be necessary to increase the tourism industry's contribution to GDP by 70% from 2019 to 2025. For this, it would be necessary to increase domestic and inbound tourism volume at a rate that would be twice the country's economic growth rate in the period considered. To achieve this objective more effectively, the government pointed out the need to focus on five priority types of tourism: cultural tourism, health tourism, active tourism, cruise tourism, and ecotourism (Sheresheva, 2018).

2.3 The tourism market in India

India experiences substantial growth in the tourism sector. This growth is mainly due to its rich culture, natural beauty, and numerous festivals. The country has a great diversity of ecosystems and mythologies, its history is rich, and its geography presents all kinds of landscapes, covering mountains and plains. Additionally, there is a kind of alternative medicine called Ayurveda, known as the Science of Life (Abhyankar; Dalvie, 2013). India is promoting an expansion in railroads and is increasing the number of trains available, the number of flights, and the number of vessels for maritime transport. There has been, also, an increase in the number of hotels, bars, and restaurants, and some internationally renowned hotels have established themselves in the country. In the 2010s, there was an annual growth of around 6% per year in inbound tourism (Hole, 2019). This growth in inbound tourism was mainly due to visitors from the United States, UK, Middle East, South Africa, Spain, France, and Portugal. India's average tourism growth rate has been almost double that of worldwide, highlighting its enormous importance to the Indian economy (Chavan; Bhola, 2014).

One of the government's recent initiatives to boost tourism in the country involves promoting private investment through tax exemptions and subsidies. The hotel and tourism industries have been considered a high priority for foreign investment. Tourism in India has enormous potential to generate jobs and ensure a flow of foreign currency into the country. In addition, it can leverage the social and economic development of the country (Chavan; Bhola, 2014). However, several challenges difficult the growth of inbound tourism activities in India to intensify sustainably. The most significant challenges are financial issues that impact the growth of the tourism and hospitality industry. In addition, financing costs are high, and problems are related to working capital, brands, and many taxes. From a strategic point of view, issues such as global uncertainties, India's image abroad, availability of human resources, financial viability, customer demand, operating costs, security, and supply chain are essential for developing the tourism sector. (Hole, 2019). As for human resources, the lack of training, standardized professional practices, and uncompetitive salaries result in high attrition rates and low job satisfaction. In addition, the labor offered in the area is of low quality due to the lack of initiatives and actions on the part of the government and educational institutions that do not revise the curricula of the courses in order to meet the international standards required for the sector (Srivastava, 2008).

It is essential to consider that tourism activities also adversely affect the country when defining strategies for the sector. Among the negatives, the following stand out:

- the possibility of destruction of the social fabric in some smaller communities.

- the increase in tensions and hostilities; and

- suspicion of local communities for lack of respect and understanding of their culture.

Furthermore, most activities' benefits do not stay with local communities but with international airlines, hotels, and other international companies (about 80%). There is also pressure over the carrying capacity of local ecosystems and a demand of tourists for standards of equipment, food and drink, and other products unavailable in the country (Venkatesh; Raj, 2016).

As for the possibilities of tourism in India, there is so-called ecological tourism, which is encouraged due to the enormous richness of the flora and fauna of the country. Several locations stand out in this segment, such as the Andaman and Nicobar Islands forests, Orissa, Meghalaya, and the Malabar Coast. Also noteworthy are the wild animal sanctuaries of Kaziranga and Jim Corbett, the mountain ranges in the north of the country, mountain resorts such as Shimla, Kulu, Manali, Ooty, the paradisiacal beauties of Kashmir, the beautiful beaches of Goa, the backwaters of Kerala, among other marvelous places. Pilgrimage Tourism in India is favored by its strong mythological background since the country is known as the Land of Gods and Goddesses. As highlights, there are several locations such as Kedarnath, Badrinath, Amarnath, the Golden Temple of Amritsar, Dwarka, Dargahs, and Masjids in Delhi and Ajmer, churches and temples in Goa, among other splendid locations (Abhyankar; Dalvie, 2013).

Pilgrimage Tourism significantly impacts India's environment and natural ecosystems, even though this type of tourism promotes economic growth and income generation. This negative impact comes from the growth in the number of facilities for accommodating tourists, the intensification of urbanization, and the increase in the flow of people around the pilgrimage centers, which increases the level of waste deposited in water bodies and on land. Because of these facts, various stakeholders should study ways to raise tourist awareness and sustainably develop this type of tourism (Hole, 2019).

There is also the possibility of carrying out Historical Tourism since India was the birthplace of several legendary governors and warriors. The tourist attractions that stand out the most are the Taj Mahal in Agra, the carved caves in Ajanta-Ellora and Khajuraho, the forts in Delhi, Rajasthan and Maharashtra, one of the oldest historical cities in India, Madurai, among others. Medical Tourism is a new type of tourism activity growing in the country. Due to the low costs and efficiency of medical facilities, more and more people consider India a better option for medical issues (Abhyankar; Dalvie, 2013). Many of these people are not wealthy but are looking for high-quality medical care at affordable prices. In India, Karnataka, Kerala, Delhi, West Bengal, and Maharastra receive more and more foreign patients for consistently investing in the sector and offering high-quality services (Swain; Sahu, 2008).

Other forms of tourism are Ayurveda Tourism and Yoga. Ayurveda, known as the "Science of Life," developed in 600 BC. Kerala in southern India is a popular destination for Ayurveda tourism. The various houses of spiritual gurus, the Ashrams, encourage Yoga Tourism. The Himalayan Mountain chain, Rishikesh, Kedarnath, and Gangotri, located in the north of India, is the preferred destination for this type of tourism. Finally, the country's geographic diversity favors Adventure Tourism activities, which include mountaineering, skiing, hiking trails in the Himalayan Mountain range, camel safari in Rajasthan, and rafting on the Ganges River near Rishikesh (Abhyankar; Dalvie, 2013).

2.4 The tourism market in China

Communist regimes in China from 1949 to 1978 did not accept tourism as an appropriate economic activity. Both domestic and international tourism were virtually nonexistent. The limited foreign visits were authorized to announce the success of communism before a previously selected international audience. The tours focused on the material achievements of communism, such as factories, communes, and revolutionary communities of peasants and workers. The government used to regulate the contact between tourists and the local population, segregating tourists in hotels according to their origin (Sofield; Li, 1998). After the introduction of economic reform by Deng Xiaoping in 1978, following the Cultural Revolution, tourism in China overgrew and became a significant economic activity. However, that period's tourism infrastructure and facilities did not support developing tourism as an economic activity. Prior to 1978, travel agencies and hotels were funded and operated by the central government. From 1978 to 1983, when funds were unavailable to establish tourism educational institutes, and there was a great need for skilled labor, financial support, and human resources were provided to run tourism programs with some universities (Zhang et al., 1999).

In 1984, the State Council decided that central government, localities, individual government departments, collectives, and even individuals could invest in and operate projects for tourism development. The Civil Aviation Administration of China (CAAC) has encouraged individual and local government departments to operate airlines (Zhang et al., 1999). Furthermore, in 1984, Deng initiated the "Love Our Country, Repair Our Great Wall" campaign, which restored three large sections of the Great Wall and promoted some infrastructure improvements that made it more accessible to tourists (Sofield; Li, 1998).

From 1985 to 1988, the growth rate in the number of hotels exceeded the growth rate in tourist arrivals. As a result, hotel availability has outstripped transportation availability, especially in civil aviation. There were high hotel occupancy rates in prominent tourist regions with adequate transport infrastructure, such as Beijing, Shanghai, and Guangdong. However, hotel occupancy rates in prominent tourist regions with poor transport infrastructure, such as Shaanxi and Guangxi, were relatively low. The government has incorporated tourism into its national plan as a critical social and economic development component. In 1987, CAAC reforms took place with the intention of transforming airlines and airports into independent corporations (Zhang et al., 1999).

Additionally, investment occurred in formulating long-term policies in which the government allocated billions of dollars annually to develop projects in the 14 main tourist cities. However, despite the efforts made, the number of tourists and the income still need to reach the targets established in the national plan. Furthermore, poor service still needs to be improved in many hotels to reach the service level of those receiving foreign investment and management. Nevertheless, by the early 1990s, tourism had already developed to the point where it was considered a significant industry and an essential economic activity for China (Zhang et al., 1999).

In 1992, tourism corporations in China began to be able to stipulate their prices according to the demand of the national and international tourism market. In a few years, they already operated in a market economy environment. Twelve national resorts emerged, combining simple sightseeing with holidaymaking (Zhang et al., 1999). Also, in 1992, the China National Tourism Administration Bureau (CNTA) selected 249 sites that, combined with China's cultural and natural heritage, enabled the development and promotion of "national scenic routes." In 1993, CNTA identified 40 festivals and celebrations that could promote tourism (Sofield; Li, 1998).

However, despite airlines having improved their services considerably, punctuality and in-flight services still needed to improve in quality, especially compared to foreign companies. The service quality of many hotels needed to meet international standards, and hiring foreign hotel management companies was costly. Hotel management companies arose; in 1995, the country counted 19. These companies helped hotels to provide quality training for human resources and gradually began to provide higher quality services, replacing foreign management companies (Zhang et al., 1999).

In the 1980s and 1990s, inbound tourism was a meaningful way to obtain the desired foreign currencies. Nevertheless, China's priorities in tourism changed in 2008. In the following years, more emphasis was placed on domestic tourism, which greatly surpassed inbound tourism in the number of tourists in most destinations and attractions. Recently, China has become known in the international tourism market due to the vertiginous growth of its outbound tourism. In 2016, around 122 million tourists traveled abroad and spent around 110 billion dollars. Compared to domestic and outbound tourism in the same year, inbound tourism had a weak performance (Zhang et al., 1999). In 2018, the number of outbound tourists grew by around 14.7% compared to the same period of the previous year. The growth rate of inbound tourism was only 1.2% during the same period. However, there is an internal policy for the development of inbound tourism. The industry works on several strategies to increase the number of international tourists and the growth of their spending in China (Sofield; Li, 1998).

Beijing and Shanghai are the destinations that receive the most inbound tourists in China. Other traditional destinations are Xi'an, Guilin, Guangzhou, Suzhou, and Hangzhou. New emerging destinations that have gained prominence due to their beautiful natural scenery and unique ethnic cultures are in western and central China, such as Lijiang, Lhasa, Kunming, Diqing, Dali, and Aba. However, new destinations are slowly becoming popular with the development of airports, high-speed trains, and other transportation services. Cities far from the principal urban agglomerations are less likely to be visited. Three major regions have a significant engagement of intraregional flow of inbound tourists whose centers are the cities of Beijing, Shanghai, and Guangzhou (Qin et al, 2019).

2.5 The tourism market in South Africa

Since the 1994 democratic elections, South Africa has considerably improved its position as the most visited destination in the world, rising from 52nd place to being among the twenty most visited destinations worldwide. The country has seen growth in the number of hotels, guest houses, game farms, restaurants, tour operators, and airlines serving the country. South Africa then became the leading tourist destination on the African continent despite the various problems arising from political instability, poverty, disease, and low levels of development. A significant challenge became sustaining the growth of inbound tourism and further improving the country's position in the most visited destinations in the world. Most tourists traveling to South Africa are from Germany, the United Kingdom, France, and the Netherlands, mainly due to the cultural ties between these nations and South Africa (Saayman, 2008).

Tourism is one of the fastest-growing sectors of South Africa's economy. From 1993 to 2006, tourism's contribution to GDP increased from 4.6 to 8.3 percent. However, between 2007 and 2010, this percentage contribution to GDP remained constant at approximately 3%. Whether directly or indirectly, tourism contributes to about 7% of the country's total jobs, and the government considers the sector essential to improve economic growth rates. Unfortunately, studies have revealed that kidnappings, car thefts, murders, and sexual offenses harm inbound tourism, both in the short and long term, and because of this, governments should pay attention to the importance of reducing these types of crimes to favor the growth of tourism. (Moyo; Ziramba, 2013).

It is important to highlight that a study found that climatic conditions in South Africa favorably impact the growth of inbound tourism. This same study suggested that the government should give importance to the competitiveness of prices in general and the cost of transport, which directly impact the demand for tourism to South Africa. Furthermore, the country is considered an inferior destination by some of the inhabitants of South America, and this continent offers similar products regarding sunny weather and beaches (Saayman, 2008).

|There is also enormous potential for medical tourism in South Africa. Following India's excellent example, the country has great possibilities for this type of tourism. If South Africa produces more medical practitioners and maintains its good reputation in the medical field, the country could remain well-placed to respond to the global boom in medical tourism. However, for medical tourism in South Africa to grow and remain competitive, social justice must prevail, and economic development must accelerate, maintaining the environment's integrity. Many hospitals in the country have an extensive and impressive track record in attracting medical tourism, even before this type of tourism became famous worldwide. As long as these hospitals continue to provide quality medical care at competitive prices, they will be attractive to many emerging medical travel markets. Much more is necessary to increase the volume of medical tourism in South Africa (Nicolaides; Zigiriadis, 2011).

According to a survey of tourists visiting South Africa, their feelings towards the country were highly positive for 80.7% of those surveyed, neutral for around 18.2%, and bad for the rest. As for the best tourist destinations in South Africa, tourists answered Cape Town, Durban, and Johannesburg in that order. Cape Town is one of the favorite destinations for international tourists, having already received numerous awards, and is considered one of the ten best cities for surfing. Almost a third of tourists surveyed reported that price was the main factor in choosing South Africa. These tourists indicated they considered alternative destinations for their trips, such as Dubai, Mauritius, Namibia, and Zimbabwe. Even with these tourists indicating alternative destinations, only seven responded that they would not revisit South Africa, and the predominant reason is crime and corruption (De Klerk; Haarhoff, 2019).

3 AIR TRANSPORT AND SUSTAINABILITY

The first section of this chapter highlights the impacts of international air transport activity on the environment. It also shows that, despite the sudden decrease in the number of flights during the global COVID-19 pandemic, which mitigated GHG emissions in the atmosphere, the number of flights tends to return to pre-pandemic numbers and continue to grow across the world over the next few decades. The following section of this chapter presents the basket of measures proposed by ICAO to reduce GHG emissions from international civil aviation and their complementation through a market measure called Carbon Offset Reduction Scheme for International Aviation (CORSIA), which can potentially restrict the expansion of the aviation industry, especially in developing countries. Finally, the third section highlights the operational measures to reduce GHG emissions implemented by Brazil and the estimated CO_2 reduction calculated based on the methodology established by ICAO.

3.1 Impacts of the growth of the air transport activity on the environment.

The growth of air transport activity globally promotes an increase in greenhouse gas (GHG) emissions. The Intergovernmental Panel on Climate Change (IPCC) estimates that CO2 emissions from air transport account for about 2% of total emissions from the use of fossil fuels. When considering the emissions of other GHGs, this percentage rises to 6%. Although this percentage seems low, its impacts are intense since emissions occur at high altitudes, between 25,000 and 41,000 feet, where most commercial aviation flights operate (Lee, 2017). In addition to CO2 emissions, air transport activities generate nitrogen oxide (NOx) emissions, contributing to ozone formation when emitted at high altitudes (ICAO 2019, a). There is also the formation of condensation trails that can induce the formation of Cirrus-type clouds that intensify the effects of global warming (ICAO 2019, a). Even though the impacts generated by CO2 emissions are well understood, there is uncertainty about the impacts generated by non-CO2 emissions. It is, therefore, necessary to develop methodologies to assess the effects of GHG and polluting gases emitted simultaneously and to understand better how these gases interact (Van Fan et al., 2018).

The environmental impacts of air transport activities tend to intensify in the long term since growth forecasts for commercial aviation operations were to triple between 2020 and 2050. However, the forecast may need revision due to the impacts of the COVID-19 pandemic (Gössling; Humpe, 2020). The reduction in the number of flights in Europe reached 89% in April 2020, compared to the number of flights in the same month of the previous year (Nizetic, 2020). In the United States, there was a reduction in passenger flights by 96% in April 2020 compared to April 2019 (USDT, 2020). Due to this sharp decrease in the number of flights worldwide, the CO2 emissions by international aviation were reduced by 45%. When considering only the reductions related to international civil aviation activities, this reduction reached 72%. However, the number of flights started to grow again worldwide after the critical phase of the COVID-19 pandemic and has now surpassed 80% of movements in the pre-pandemic period in most parts of the world (Liu et al., 2020).

3.2 ICAO Basket of Measures to reduce CO2 emissions and the possible impacts of CORSIA on the development of air transport on the BRICS nations.

Several international agreements seek to mitigate the emission of GHG. Among them, the Kyoto Protocol and the Paris Agreement stand out. They consider principles of justice. Countries with higher per capita GHG emissions may contribute more to emission reductions. Paris Agreement signatory countries must address the problem of greenhouse gas emissions from their domestic aviation activities through Nationally Determined Contributions (NDC). The reduction of GHG emissions by International Civil Aviation is the responsibility of ICAO (Gössling; Humpe, 2020). ICAO developed CORSIA to complement the basket of measures to offset the amount of CO2 emissions not reduced through operational and technological measures and sustainable fuels. The implementation of CORSIA, which is a market-based measure, is taking place in three phases, and entry into the program will be mandatory from 2027 for all States that have a share of 0.5% of the world's revenue tonne kilometer (RTK) or that are part of the 90% of RTK accumulated globally except for Least Developed Countries (LDCs), Small Island Developing States

(SIDS) and Landlocked Developing Countries (LLDCs) unless they volunteer to participate. The expectation is that this program will last until the year 2035, when the production of alternative fuels will scale and be used ostensibly in aviation. Currently, 115 countries have joined CORSIA (ICAO, 2022).

The operational measures proposed by ICAO are related to optimizing operational procedures and air traffic management (ATM) measures to reduce GHG emissions (Lyle, 2018). The Global Air Navigation Plan (GANP) contains most of the existing operational measures and will be available soon. The operational implementations provided for in the GANP aim to achieve an interoperable global air navigation system that guarantees acceptable levels of operational safety and ensures more environmentally sustainable and economical operations. ICAO estimates that GANP implementations will generate an emission reduction of millions of tons of CO2. The availability of resources by the States and their operational needs will guide the implementation of operational measures (ICAO, 2019). All the BRICS countries develop implementations of operational measures foreseen in the GANP. The Ministry of Transport of Russia and South Africa, the Airport Authority of India, the Civil Aviation Administration of China, and the Department of Airspace Control in Brazil (DECEA) carry out several initiatives.

Additionally, multisectoral plans and agreements between various public and private stakeholders, such as regulatory bodies, aircraft operators, air navigation service providers, and aircraft manufacturers, are required (ICAO, 2019). However, the straightforward implementation of operational measures *per se* does not guarantee the reduction of CO2 emissions because as air traffic grows, congestion levels intensify, ATM efficiency decreases, and GHG emissions intensify due to increased fuel consumption by the aircraft. This decrease in efficiency is especially true around airports with a high volume of arrivals and departures, inside terminal airspaces, and along congested flight corridors. Therefore, in addition to implementing operational measures, ATM efficiency should be optimized by implementing performance monitoring mechanisms, with defined goals for each flight's phases (ICAO, 2014).

The implementation of technological measures is essential for the reduction of CO2 emissions by aviation. Extraordinary advances have been taking place over the last few decades. About 80% of the aircraft in operation are more efficient in fuel consumption per passenger kilometer than the aircraft in operation in the 1960s. The ongoing advances include engines that improve the bypass ratio and lighter and more heat-resistant materials to compose the aircraft fuselage. In addition, advances in electric and hybrid aircraft technology will allow for lower consumption of fossil fuels and, consequently, a reduction in CO2 emissions (ICAO, 2022a). Although technological measures significantly reduce emissions, their costs are high, and incorporating these technologies in aircraft fleets may take time (Hasan et al., 2021).

As for measures associated with using SAF, they are the most important for reducing CO2 emissions by aviation. However, although technologies for producing these fuels are already available, they are produced in small quantities, and the production costs still need to be lowered. Producing SAF on a scale can mitigate environmental issues and improve social and economic issues in developing countries, as long as this production does not impact food security (ICAO, 2022a). According to a conservative but optimistic point of view, about 5.7% of all arable land in 2050 will be available for the production of biofuels worldwide, which will be enough to supply about 92% of the estimated demand for 2100 (da Cunha Dias et al., 2021). However, to promote an increase in SAF production, it is necessary to promote the use and regulation through policies and laws, in addition to financial and technical support from governments, for the production and certification of these fuels (ICAO, 2022a).

Regarding market measures, CORSIA stands out as a relatively simple global compensation scheme for emissions related to international air transport. In its original conception, the emissions baseline would be the measurements undertaken in 2019 and 2020. However, due to the drastic reduction in flows related to international air transport, ICAO readjusted CORSIA by removing measurements from the emissions baseline relating to 2020, considering only those relating to 2019 (Zhang et al., 2021). Nevertheless, the program may last until 2035, when SAF production will likely scale and production costs will be significantly reduced, making its use viable in international air transport (Lyle, 2018). None of the BRICS countries volunteered to enter the program's first phase. Even so, except for South Africa, the other BRICS countries will enter the mandatory phase of the program as they are part of 90% of the (revenue tonne-kilometers) accumulated in the world. Figure 9 shows the participation of countries in CORSIA. It is essential to highlight that G7 countries accumulate 30% of the world's RTK while BRICS nations accumulate 17%. Excluding China's percentage from the sum, this number drops to only 5% (ICAO, 2019a).

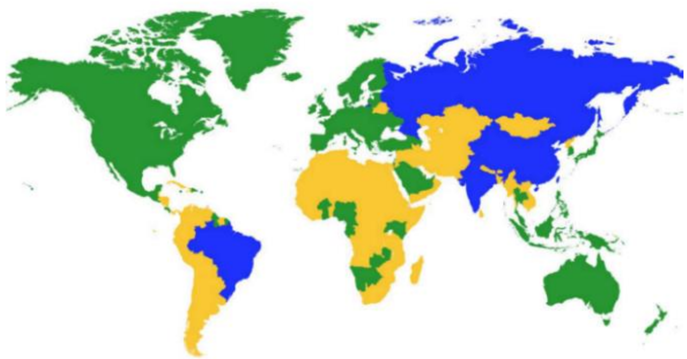

Figure 9 - Countries participating in CORSIA's first phase (green), second phase (blue) and non-participants countries (yellow) Source: ICAO.

In CORSIA, each country monitors, verifies, and reports its operators' offset data and emissions. However, some countries, particularly developing countries, feel that the principles of carbon-neutral growth should not apply to them. There is also some apprehension in the aviation community that existing restrictions due to inadequate or inefficient air transport infrastructure added to new environmental restrictions may severely restrict the growth of the air transport sector in these countries (Lyle, 2018). Adequate air transport infrastructure favors the movement of people and goods between different regions. So, restrictions that limit the growth in the number of international flights in developing countries will also impact the development of air transport infrastructure in these countries and, consequently, their economic growth (Polyzos; Tsiotas, 2020). It is important to note that according to a 2022 IPCC report, more than the implementation of CORSIA is necessary to reduce CO2 emissions effectively and achieve the targets defined by the Paris Agreement. In order to achieve the aspirational goals of neutral carbon growth, the CORSIA eligibility criteria need to be improved, and airlines need to be encouraged to invest more in technologies that will allow the reduction of emissions (Wonzy et al., 2022).

The ICAO Council is reviewing the feasibility of developing a Long-Term Aspirational Goal (LTAG) for international aviation. This analysis considers an assessment of proposed targets, including impacts on the growth of countries and the costs of their implementation for the states (ICAO, 2018). A working group composed of professionals worldwide and of recognized competence is gathering information from internal and external sources for ICAO. This work will help identify and evaluate existing, planned, and innovative operational, technological, and SAF use measures in international air transport that may contribute to reducing CO2 emissions. Based on this collected information, the ICAO specialists will create scenarios combining technological, operational, and use of SAF measures to analyze the data and make forecasts of future demands, considering the target of increasing energy efficiency by 2% per year and carbon neutron growth from 2020. The specialists will also estimate the costs and economic impacts of implementing the measures mentioned above on the growth of the air transport sector, especially for developing countries (ICAO, 2022).

3.3 Implementation of operational measures on the air transport in Brazil and CO2 emissions reduction estimates

In Brazil, the Department of Airspace Control (DECEA) regulates civil aviation activities regarding the use of airspace. In 2012, DECEA created the SIRIUS Program, aligned with GANP, to present a strategic vision for evolving the National Air Traffic Management Systems (ATM) to meet the local peculiarities. Several projects contemplate the implementation of airside operational measures. Among them are the Optimization of National Airspace, Evolution of Air Traffic Flow Management, and Flexible Use of Airspace (DECEA, 2022). Regarding the National Airspace Optimization project of the SIRIUS Program, Brazil implemented and continues to implement the performance-based navigation concept (PBN). This concept envisages the use of Global Satellite Navigation Systems (GNSS) and systems embedded in aircraft that allow them to fly freely between any coordinates, allowing more direct and efficient routes with this, a reduction in CO_2 emissions (ICAO, 2016).

Along with PBN, implementing two other concepts is frequent: Continuous Climb Operations (CCO) and Continuous Descent Operations (CDO). They consist of the elaboration of PBN arrival and departure procedures that allow aircraft to climb and descend without stopping in intermediate steps, whenever possible, using engine thrust and speed regimes that reduce fuel consumption and, consequently, CO_2 emissions. (ICAO, 2019).

Although little data refers to actual flights that perform arrival trajectories with CDO in the literature, there is a consensus that descent trajectories with greater angles of descent are more efficient for reducing fuel consumption. Some data show a strong correlation between the fuel flow of aircraft in general and the angle of descent when it varies between 2.5° and 3.0°. However, an opposite correlation trend occurs for greater descent angles, and the fuel flow decreases (Turgut et al., 2019). As for the concept of CCO when applied in airport departure procedures, accurate data from operations demonstrate a reduction of up to approximately 30% in fuel consumption due to the non-leveling of the aircraft in intermediate segments that allow the use of optimal powers and speeds until they reach cruising levels (Villegas Díaz et al., 2020). Despite the advantages of applying the concepts of CCO and CDO, their joint use needs to be carefully analyzed, especially for congested airports. It is crucial to ensure an optimal distribution between procedures using the CDO and CCO concepts to reduce impacts on airport capacities (Pérez-Castán et al., 2018).

In Doc 9988, "Guidance on the Development of States' Action Plan on CO_2 Emissions Reduction Activities," ICAO presents a methodology that makes it possible to estimate the reduction in CO_2 emissions from implementing operational measures. This methodology allowed the calculation of the estimate of CO_2 emissions reduction obtained by the implementation of operational measures contemplated in the projects of the SIRIUS Program, considering the year 2021 as a base. The calculations required using an estimate of aircraft fuel consumption and the annual movement of aircraft at airports with airside operational measures implemented. The information about the status of the implementation of operational measures in the Brazilian aerodromes is available on the website AISWEB. CGNA provided the number of airport movements in the year 2021. Calculations of CO_2

emission reduction estimates considered the variety of aircraft operating in Brazilian airspace and, due to this, vary between low and high ends. Several operational measures implemented in Brazil, provided for in the GANP, have a calculation methodology established in Doc 9988 and contribute significantly to reducing CO2 emissions. These operational measures are Continuous Descend Operations (CDO), Continuous Climb Operations (CCO), Standard Terminal Arrival Routes (STAR), Performance Based Navigation - Standard Instrument Departures (PBN-SID), Radius to Fix PBN Procedures, Required Navigation Performance Procedures – Authorization Required (RNP-AR). Implementing all these measures is within the scope of the National Airspace Optimization project.

One hundred fifty aerodromes have implemented PBN departures associated with the CCO concept. In 2021, there was an approximate movement of 1.25 million aircraft departures at these aerodromes. The calculations pointed to a fuel consumption reduction between 90,000 and 187,000 tons, according to the rules of thumb shown in Table 1. Multiplying these values by 3.16 (the conversion factor), it is possible to find the mass of CO2. Based on the mass of fuel, the estimated reduction in CO2 emissions is between 284,000 and 590,920 tons of CO2.

Table 1 - Rule of Thumb for CCO and PBN SID fuel consumption reduction estimation calculations. Source: ICAO.

Measures to improve fuel efficient departure and approach procedures: *CCO* (CAEP/10 Report 2016)	Use IFSET or FS = 90-150 kg (0.09-0.15 tonnes) of fuel * number of CCOs	A State averages 2,000,000 flights per year. Currently, 50 of its airports offer CCO which accounts for approximately 200,000 departure movements. Expert judgement estimates that CCO is performed by 80% of the departures, a total of 160,000 departure movements. The annual fuel savings can be estimated as: — 0.09 * 160,000 = 14,400 tonnes of fuel saved (low end of range) — 0.15 * 160,000 = 24,000 tonnes of fuel saved (high end of range)
Measures to improve fuel efficient departure and approach procedures: *PBN SID* (CAEP/10 Report 2016)	Use IFSET or FS = 0 kg to 30 kg of fuel (0 to .03 tonnes) * number of departure movements on PBN SID	A State averages 1,000,000 flights per year. Currently, 50 of its airports have implemented PBN SID which is estimated to be used by 200,000 departure movements. Expert judgement is that 100% of these departures fly the PBN SID. The annual fuel savings can be estimated as: — 0.0 * 200,000 = 0 tonnes of fuel saved (low end of range) — 0.03 * 200,000 = 6,000 tonnes of fuel saved (high end of range)

Thirty-three aerodromes have implemented PBN STAR associated with the CDO concept. STAR is a predefined aircraft arrival trajectory for aerodromes with a considerable traffic volume. The total movement of aircraft approaching these aerodromes was approximately 892,460 in 2021. Based on the rules of thumb in Table 2, the estimated reduction in fuel consumption was between 36,590 and 63,364 tons of fuel, which, based on the already-mentioned factor, generates an estimated reduction in CO2 emissions between 115,624 and 200,230 tons.

Table 2 - Rule of Thumb for CDO and PBN STAR fuel consumption reduction estimation calculations Source: ICAO

Measures to improve fuel-efficient departure and approach procedures: *CDO* (CAEP/10 Report 2016)	Use IFSET or FS = 60 kg (0.06 tonnes) of fuel * number of CDOs	A State averages 1,000,000 flights per year. Currently, 10 of its airports offer CDO which accounts for approximately 4,800,000 arrival movements. Expert judgement estimates that CDO at these airports is performed 100% in off-peak hours which accounts for approximately 35% or 1,680,000 traffic movements. The annual fuel savings can be estimated as: 0.06 * 1,680,000 = 100,800 tonnes of fuel saved
Measures to improve fuel efficient departure and approach procedures: *PBN STAR* (CAEP/10 Report 2016)	Use IFSET or FS = 20 kg to 50 kg of fuel (.02 to .05 tonnes) * number of arrivals on PBN STAR	A State averages 1,000,000 flights per year. Currently, 50 of its airports have implemented PBN STAR which is estimated to be used by 250,000 arrival movements. Expert judgement is that 100% of these arrivals fly the PBN STAR. The annual fuel savings can be estimated as: — 0.02 * 250,000 = 5,000 tonnes of fuel saved (low end of range) — 0.05 * 250,000 = 12,500 tonnes of fuel saved (high end of range)

Thirteen aerodromes in Brazil have PBN arrival procedures associated with radius to fix sections, consisting of circumference arcs that tend to reduce the number of miles flown by aircraft. The total movement of arrivals to these aerodromes in 2021 was 389,980. The estimated calculation of fuel consumption reduction, using the rule of thumb of Table 3, is between 11.738.413 and 23.301.335 tons of fuel, which, multiplied by the factor 3.16, results in CO2 emissions reduction between 37.093.385 and 73.632.219 tons of CO2.

Table 3 - Rule of Thumb for Radius to Fix PBN Procedures fuel consumption reduction estimation calculations. Source: ICAO.

Implementation of radius to fix PBN procedures	Use IFSET or FS = ∑[(Total movements * 0.1 * fuel savings for small aircraft (11-40 kg)) + (total movements * 0.8 * fuel savings for medium aircraft (62-121 kg)) + total movements * 0.1 * fuel savings for heavy aircraft (95-187 kg))] * 0.5	An airport with 100,000 arrival movements is planning to implement radius to fix PBN procedures. It is assumed that 50% of arrivals to this airport will fly this approach procedure. The breakdown of traffic at this airport is estimated to be 10% : 80% : 10% in relation to small : medium : heavy aircraft. The annual fuel savings can be estimated as: — ((100,000 * 0.1 * 11 kg) + (100,000 * 0.8 * 62 kg) + (100,000 * 0.1 * 95 kg)) * 0.5 = 3,010 tonnes of fuel saved (low end of range) — ((100,000 * 0.1 * 40 kg) + (100,000 * 0.8 * 121 kg) + (100,000 * 0.1 * 187 kg)) * 0.5 = 11,950 tonnes of fuel saved (high end of range)

Finally, twelve aerodromes in Brazil have RNP AR APCH-type arrival procedures, which are PBN arrival procedures that require special authorizations for their execution by aircraft crews due to particular characteristics. The total number of aircraft arrivals using these procedures in 2021 was 376,343. Based on the rules of thumb in Table 4, we arrive at an estimate of fuel consumption reduction between 358,466 and 442,203 tons, which from the conversion factor provides an estimate of CO2 emissions reduction between 1,132,754 and 1,397 .362 tons of CO2.

Table 4 - Rule of Thumb for RNP AR APCH Procedures fuel consumption reduction estimation calculations Source: ICAO.

Measure (References)	*Rule of thumb*	*Example*
Implementation of RNP AR APCH procedures for reducing approach minima and the possibilities of missed approach/diversion	Use IFSET or FS = total arrival movements * 0.5 * 0.005 * fuel savings (381-471 kg)	An airport with 100,000 arrival movements is planning to implement an RNP AR APCH procedure. It is assumed that 50% of arrivals to this airport will fly this approach procedure. It is estimated that in the event of a missed approach or diversion the average extra fuel burn used ranges from 381-470 kg. It is assumed that the minima are sufficiently reduced to require an aircraft to carry out a missed approach or diversion in 0.005 operations. The annual fuel savings can be estimated as: — 100,000 * 0.5 * 0.005 * 381 kg = 95.25 tonnes of fuel saved (low end of range) — 100,000 * 0.5 * 0.005 * 470 kg = 117.5 tonnes of fuel saved (high end of range)

Therefore, in 2021, Brazil's estimated reduction in CO2 emissions due to implementing airside operational measures was between 37.8 and 75.8 million tons. However, it is essential to emphasize that the estimates mentioned above and presented in Figure 10 only include operational measures associated with aerodromes and do not include those associated with the airspace itself. So, operational measures such as the Flexible Use of Airspace (FUA) and Direct Routes, among others, were not included in the calculations. They also do not include operational measures associated with aerodromes, which do not significantly reduce CO2 emissions because they have yet to be implemented on a large scale, being present only in a few airports. Among these measures, we can highlight the Arrival

Manager (AMAN), Airport Collaborative Decision-Making (ACDM), and Automatic Dependent Surveillance–Broadcast (ADS-B).

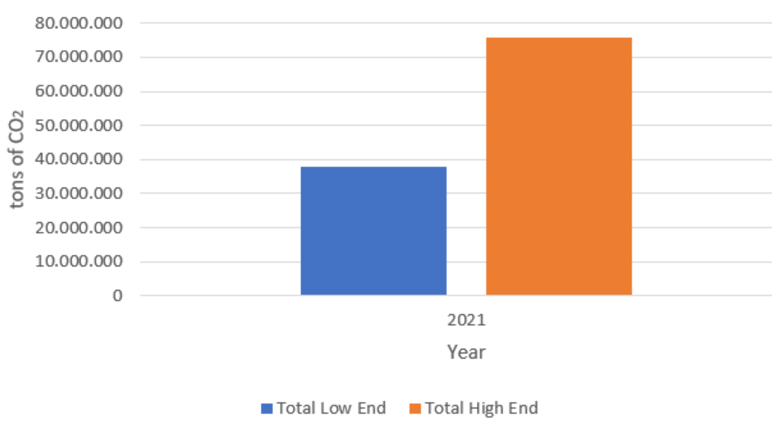

Figure 10 - Total CO2 Emissions Reduction estimates from Operational Measures in the year 2021. Source: author.

Therefore, as demonstrated by calculations of emission reduction estimates from the implementation of operational measures, it is possible to mitigate environmental impacts with actions that increase the efficiency of operations without harming the possibility of expanding air transport infrastructure and the number of international flights in developing countries, as in market measures such as CORSIA. The other BRICS countries, most of which are the ICAO Council and Brazil members, have been implementing operational measures provided for in the GANP, which help mitigate CO2 emissions. However, with the implementation of operational measures, it is necessary to monitor the performance of aircraft flights to ensure that the efficiency gains arising from operational measures are practical.

4 AIR CONNECTION BETWEEN BRICS COUNTRIES AND THE FEASIBILITY OF STRUCTURING A NETWORK OF ROUTES

The first section of the present chapter brings a connectivity analysis of the BRICS countries using an ICAO flight database from 2022. Subsequently, in the next section, with the help of simulation software, the possibility of allocating direct flights between the BRICS countries is verified, considering the available airport infrastructures and the critical aircraft capable of operating in these infrastructures.

4.1 Analysis of connections between BRICS countries

Air Connectivity, as mentioned before, is an indicator associated with the economic development of countries, which consists of the concentration of the route network and its ability to link origins and destinations and transport passengers between them. ICAO provides a DATASET with several indicators, one of them called connections. This indicator provides some information, including the number of flights between a given country and other countries and how many of these flights are carried out by companies from one of the countries between which the flight is established or by foreign companies. All the data regarding the connection from the BRICS countries are in Annex 1.

Observing the connectivity data between Brazil and the other countries of the world for the year 2022, displayed in Figure 11, it is evident that there were no flights from Brazil to the other BRICS countries, with or without connections. The figure also shows the countries contributing up to 50% of the total flights departing and arriving from Brazil. The ICAO DATASET pointed out that 80% of the flights occurred between Brazil and some countries in South and Central America, some European countries, and the United States. Considering South and Central America countries, most flights went to Argentina, Panama, Colombia, Chile, Uruguay, and Peru. The United States was the second country with the highest number of flights. Finally, of the European countries, Portugal stood out, followed by France, Spain, and Germany. Considering all the flights in 2022, there were flights between

Brazil and all the G7 countries, except for Japan, totaling almost 30% of the total flights. The data obtained indicated that the number of flights by Brazilian companies corresponded to only about 20% of the total flights.

Figure 11 - Brazil – connections. Source: ICAO.

Analyzing the connectivity data between Russia and the other countries of the world for the year 2022, detailed in Figure 12, there were flights between Russia and two other BRICS countries, China and India. The figure also shows the countries contributing up to 50% of the total flights departing and arriving from Russia. The ICAO DATASET pointed out that about 80% of the flights occurred between Russia and ten other countries, mainly in Asia and Eastern Europe. Except for Canada, there were flights to all G7 countries. Total flights between Russia and the G7 countries accounted for only 2%. The number of flights between Russia, China, and India represented 5% of the total flights in 2022. The data showed that the number of flights carried out by Russian companies corresponded to only 13% of the total number of flights. However, considering only flights between Russia and other BRICS countries, in this case, China and India, only 1.5% were made by companies not belonging to these countries.

Figure 12 - Russia – connections Source: ICAO.

Looking at the connectivity data between India and the other countries of the world for the year 2022, detailed in Figure 13, there were flights between India and two other BRICS countries, China and Russia. The figure also shows the countries contributing up to 50% of the total flights departing and arriving from India. The ICAO DATASET pointed out that about 80% of the flights occurred between India and 17 other countries on different continents. There were flights to all G7 countries. Total flights between India and the G7 countries accounted for approximately 9% of total flights. The number of flights between India, Russia, and China represented only 3% of total flights in 2022. The number of flights carried out by Indian companies accounted for about 45% of total flights. Considering only flights between India and other BRICS countries, in this case, China and Russia, only 3.3% were carried out by companies not belonging to these countries.

Figure 13 - India – connections Source: ICAO.

Analyzing the connectivity data between China and the other countries of the world for the year 2022, detailed in Figure 14, there were flights between China and all the other BRICS countries, except for Brazil. The figure also shows the countries contributing up to 50% of the total flights departing and arriving from China. The ICAO DATASET pointed out that about 80% of the flights occurred between China and 17 other countries, mainly in Asia, Europe, and North America. There were flights to all G7 countries. Total flights between China and the G7 countries accounted for approximately 31%. The number of flights between China, Russia, India, and South Africa represented only 3.4% of the total flights in 2022. The number of flights by Chinese companies accounted for about 58% of the total flights. Flights. Considering only flights between India and other BRICS countries, in this case, India, Russia, and South Africa, only 3.6% were carried out by companies not belonging to these countries.

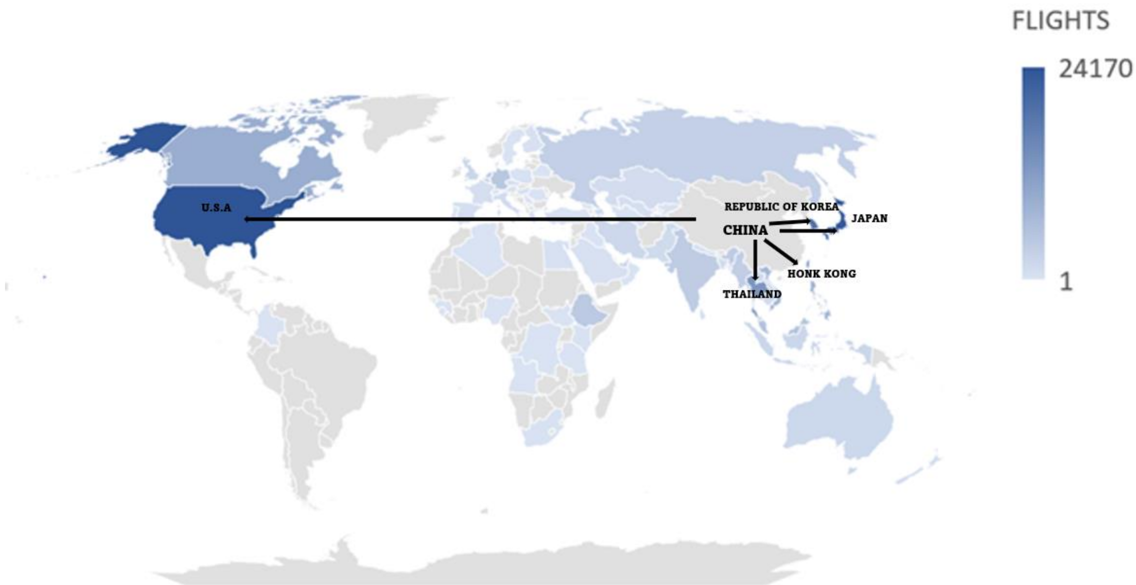

Figure 14 - China – connections. Source: ICAO.

Finally, looking now at the connectivity data between South Africa and the other countries of the world for the year 2022, detailed in Figure 15, it is observed that there were no flights to other BRICS countries, except for China. The figure also shows the countries contributing up to 50% of the total flights departing and arriving from South Africa. The ICAO DATASET pointed out that around 80% of the flights occurred between South Africa and 14 other countries, eight located in Africa and the rest in Europe, the Middle East, and Asia. There were flights to four G7 member countries. Total flights between South Africa and these four G7 countries accounted for approximately 8.8%. The number of flights between South Africa and China represented only 0.1% of the total flights in 2022. The number of flights carried out by South African companies corresponded to approximately 41% of the total number of flights. Considering only flights between South Africa and other BRICS countries, in this case, only China, no flights are carried out by companies not belonging to any of these countries.

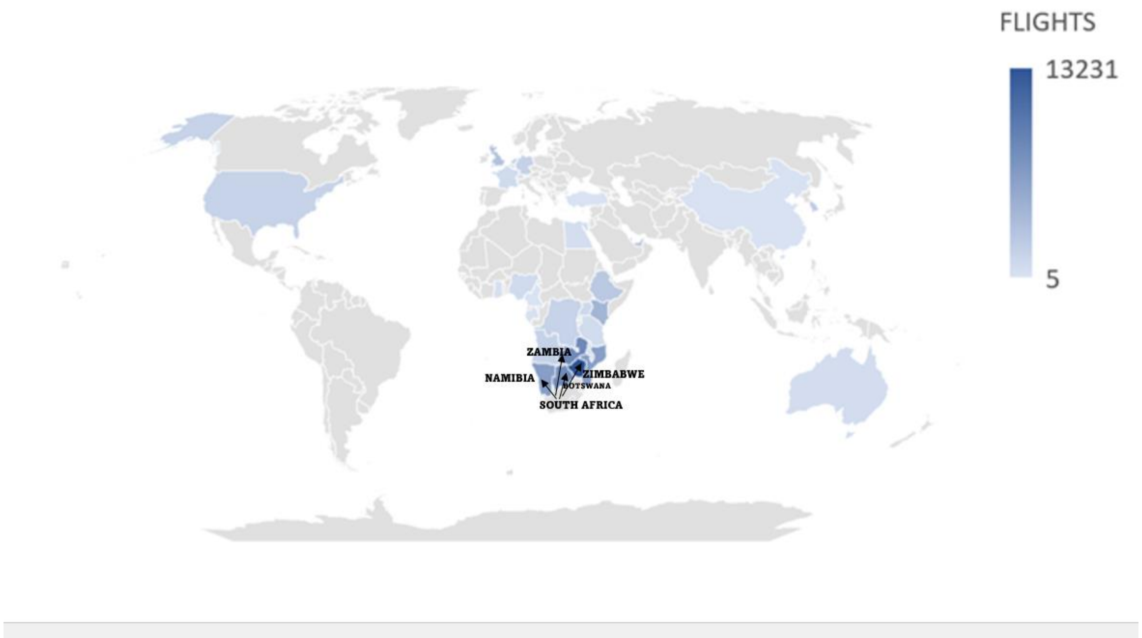

Figure 15 - South Africa – connections. Source: ICAO.

4.2 Verification of the possibility of allocating direct flights between the main international airports of the BRICS countries

ICAO connection indicators show that in 2022, there were only flights between Russia, China, and India, and there were no flights between Brazil and South Africa or between these countries and the other BRICS countries. Selecting five international airports with the most significant movement of each of the BRICS countries made it possible to analyze the feasibility of the allocation of flights between international airports of BRICS nations. The selection of the airports used data obtained on the official pages of the Ministry of Transport of Russia and South Africa, the Airport Authority of India, the Civil Aviation Administration of China, and the Department of Airspace Control in Brazil. The identification of these airports, presented in Table 5, uses their ICAO codes, 4-letter codes, to facilitate identification.

In Volume I of Annex 14, published by ICAO, lies the definition of *aerodrome reference code.* This code supports a simple method of interrelating numerous specifications concerning the characteristics of aerodromes to provide a series of facilities suitable for aircraft that intend to operate there. It comprises two elements of the aircraft's performance, characteristics, and dimensions, as shown in Table 6. The first element consists of a number based on the length of the airfield's runway; the second is a letter based on the aircraft span that the airfield can handle. Therefore, an aerodrome's reference code limits the aircraft types operating there.

Table 5 – 5 busiest international airports from each of the BRICS countries. Source: author.

COUNTRY	AIRPORT-1	AIRPORT-2	AIRPROT-3	AIRPORT-4	AIRPORT-5
BRAZIL	SBGR	SBBR	SBKP	SBCF	SBRF
RUSSIA	UUDD	UUEE	UUWW	UWKD	URSS
INDIA	VIDP	VABB	VOBL	VOCI	VOHS
CHINA	ZBAA	ZGGG	ZSPD	ZSSS	ZGSZ
SOUTH AFRICA	FAOR	FACT	FALE	FAGG	FALA

Table 6 – Reference Code Elements. Source: ICAO.

Code element 1	
Code number	Aeroplane reference field length
1	Less than 800 m
2	800 m up to but not including 1 200 m
3	1 200 m up to but not including 1 800 m
4	1 800 m and over
Code element 2	
Code letter	Wingspan
A	Up to but not including 15 m
B	15 m up to but not including 24 m
C	24 m up to but not including 36 m
D	36 m up to but not including 52 m
E	52 m up to but not including 65 m
F	65 m up to but not including 80 m

After identifying the five busiest international airports in each of the BRICS countries, the analysis of the possibility of allocating direct flights between them and the average costs of these flights started. To perform this analysis, it was first necessary to observe the daily flights allocated to the selected airports, with the help of Google Flights, identifying the aircraft with greater capacity and flight autonomy capable of operating in them (critic aircraft). In this way, it was possible to define the reference code of these airports, as seen in Table 7.

Subsequently, the definition of the pairs of airports of each of the BRICS countries to be interconnected occurred, including all five airports of all countries, two by two. The simulations took place on the Flight Calculator software, available on the Aviapages platform, and has several applications for business aviation stakeholders. Simulations using this software demonstrated the feasibility of allocating direct flights between airports and the average flight cost between pairs of airports. The data needed to carry out the simulations (inputs) were the departure airport, the arrival airport, the type of aircraft, and the number of passengers on board. As outputs, the simulator presents the average wind during the flight, the flight time, the flight cost, the distance flown on the airways, and the maximum circle distance between the airports.

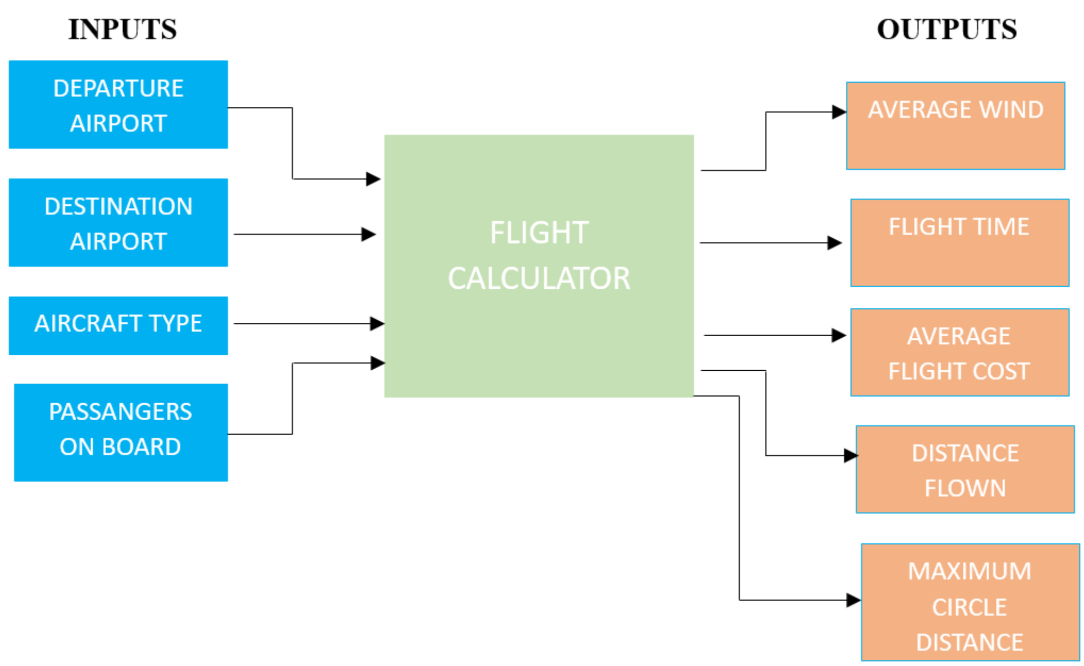

Figure 16 – Flight calculator functioning. Source: author.

Table 7 –Reference Code of the 5 busiest international airports from BRICS countries. Source: author.

COUNTRY	AIRPORT-1	AIRPORT-2	AIRPROT-3	AIRPORT-4	AIRPORT-5
BRAZIL	SBGR (4F)	SBBR (4E)	SBKP (4E)	SBCF (4E)	SBRF (4E)
RUSSIA	UUDD (4F)	UUEE (4E)	UUWW(4E)	UWKD (4C)	URSS (4C)
INDIA	VIDP (4F)	VABB (4E)	VOBL (4F)	VOCI (4E)	VOHS (4E)
CHINA	ZBAA (4F)	ZGGG (4F)	ZSPD (4F)	ZSSS (4E)	ZGSZ (4E)
SOUTH AFRICA	FAOR (4F)	FACT (4E)	FALE (4E)	FAGG (4C)	FALA (4C)

The parameters used in the simulations considered aircraft capable of operating at the pair of airports according to the lowest reference code in each situation and with all seats occupied by passengers. Aerodromes with reference code 4F allow the operation of the Airbus 380 aircraft (A380), the largest aircraft currently in operation, with the most significant passenger capacity and autonomy. However, as the simulator cannot simulate this aircraft, it was considered that the maximum possible reference code for the airports was 4E. The pairs of airports considered were then limited to this reference code. Finally, to standardize the analyses, it was decided to use the Boeing 777-200 aircraft model when the operation in the pair of airports was limited to the 4E reference code and the Boeing 737-800 aircraft when the operation was limited to the code 4C benchmark. The aircraft models chosen for the simulations considered that most airlines worldwide use these models on a large scale.

The simulation software uses the existing airway structure to draw the most direct route possible between the pairs of airports. It considers the best possible vertical profile for fuel economy, considering the wind regime that acts along the established routes. In addition, it provides the average cost associated with the flight due to the fuel consumed. Figure 16 compares the route flown to the direct route (maximum circle arc), and Figure 17 shows the vertical flight profile. All the output data obtained is in Annex 2.

Figure 16 – Airways Route (red) x Direct Route (black). Source: Aviapages.

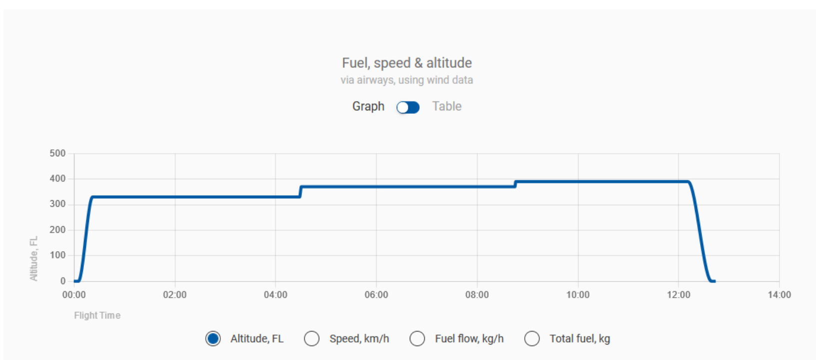

Figure 17 – Vertical Flight Profile. Source: Aviapages.

After carrying out the simulations considering all possible pairs of airports interconnecting all five most busy international airports of the BRICS countries, it became possible to calculate the percentage of viable airport connections by direct flights between the BRICS countries, two by two. The result is in Figure 18. In some cases, due to the wind pattern at altitude, a direct outward flight between two airports is possible but not a return one because the flight time is longer than the autonomy of the considered aircraft. From the cost data per flight of all flights performed by the simulation software, it was possible to obtain the average cost between viable direct flights connecting two BRICS countries, as seen in Figure 19.

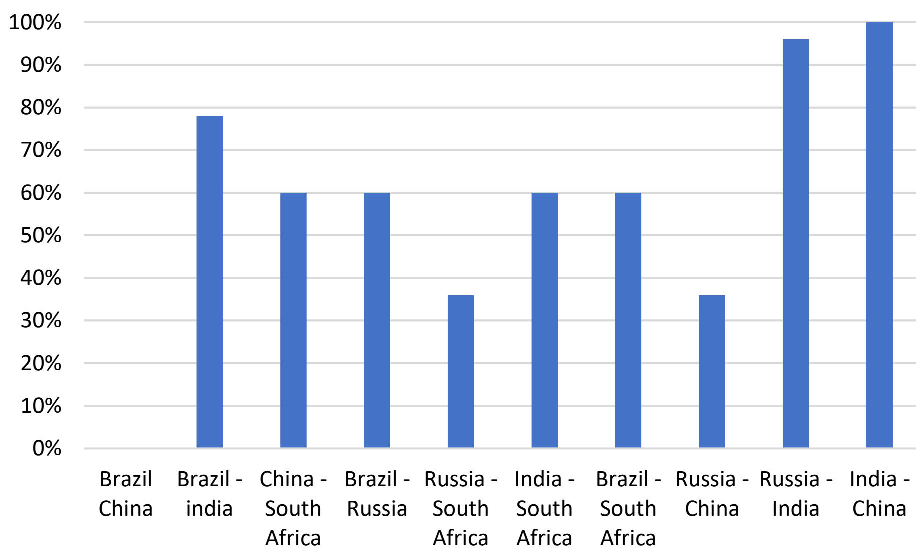

Fig. 18 – Percentual of airports of BRICS countries that can be connected by direct flights. Source: Aviapages.

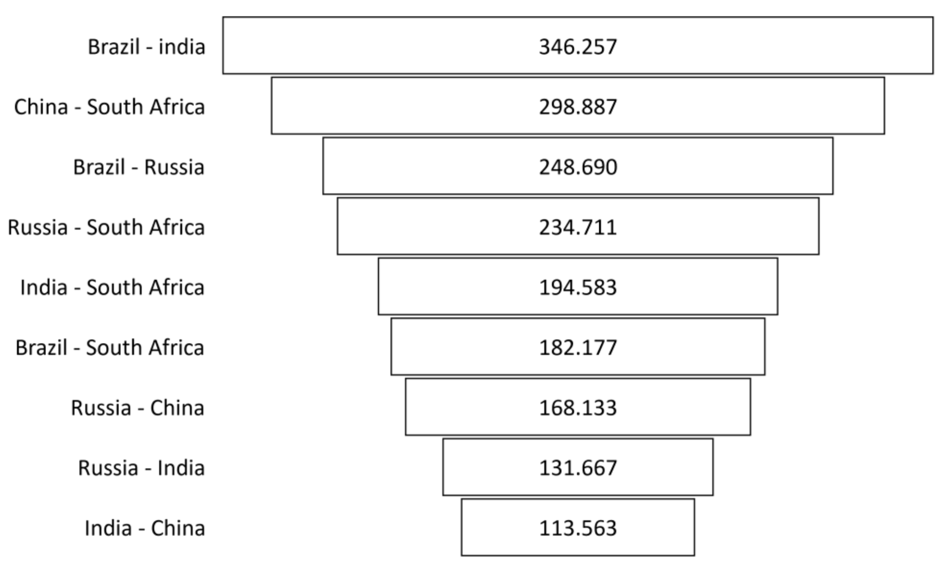

Figure 19 – Mean cost per flight (possible direct flights). Source: Aviapages.

5 DISCUSSION

The number of international airports per million inhabitants in the BRICS countries is much lower than in the G7 countries, except for Russia, which has a higher number than Japan and Germany, as highlighted in section 1.4. Observing the expenditures and receipts related to international tourism activities among the BRICS and G7 countries, shown in the same section, it is possible to notice that while the G7 nations handle 56% of expenditures on international tourism, they get about 87% of total revenue and that the seats made available in 2019 between direct flights from the BRICS countries to the G7 countries were almost ten times greater than those made available for direct flights between the BRICS countries themselves. Thus, there is evidence of a preference by populations of the BRICS countries to take tourist trips to the G7 countries to the detriment of trips to other BRICS countries.

The results from the analysis made in section 4.1 evidenced that most BRICS outbound tourism is to nearby countries. Additionally, the theory that migration patterns in international tourism activities are related to historical ties between metropolises and colonies, and due to this, outbound tourism from BRICS to the Global North is more significant than outbound tourism among the countries of the block was is confirmed by the results of the analysis in section 1.4 regarding the total number of seats available in 2019 for flights between G7 and BRICS nations and also confirmed by the BRICS countries connections from ICAO DATASET, available in Annex 2.

The data analysis from 2022 flights considering the connections of each of the BRICS countries, made in section 4.1, evidenced that except for China, most international flights from these countries happened to closer countries, as already mentioned, probably due to the lower flight costs reflected in the airline ticket prices. Brazil was the only country that did not have any flights to or from another BRICS country and had a percentage of 30% of the total number of flights to and from G7 countries. India, in turn, had a percentage of 9% of total flights to and from G7 countries and 3% to and from BRICS countries (only China and Russia). Conversely, China had 31% of all flights to and from G7 countries and only 3.4% to and from BRICS countries. South Africa had 8.8% of flights to and from G7 countries and

0.1% going to and from China. Finally, 5% of all flights in Russia were to and from G7 countries, and only 2% were to and from other BRICS countries (China and India).

Regarding the possibility of allocating direct flights between the BRICS countries, the analysis made in section 4.2 showed that except for the Brazil-China pair of countries, where there is no possibility of allocating direct flights between any of the five busiest international airports in each country, according to the simulator utilized in the analysis, it is possible to allocate direct flights between the other pairs of BRICS countries. In the case of the China-India pair of countries, it is possible to allocate direct flights between all five busiest airports from each country.

The analysis in section 4.2 also highlighted that the average cost of flights between pairs of BRICS countries ranges from €113,563.00 between India and China and €346,257.00 between Brazil and India. Since the average cost of flights between Russia, China, and India is the lowest, this may explain the higher number of flights between these countries. Furthermore, even though the average cost of flights between Brazil and India, China and South Africa, and Brazil and Russia are high, there are flights between these countries and G7 countries, among others, with similar costs, which demonstrates the feasibility of allocation of more flights between the BRICS nations.

Furthermore, boosting air transport in developing countries may encounter resistance due to environmental policies that apply mitigation measures for the emission of polluting gases by international civil aviation. Reducing GHG emissions is possible by implementing operational, technological, and market measures and using SAF. Implementing technological measures and using sustainable fuels have the most significant potential for reducing CO2 emissions. However, technological measures have a high implementation cost, and their incorporation into aircraft fleets takes a long time. Using SAF strongly depends on reducing associated production costs and developing a supply chain that allows its production to scale. As for market measures, ICAO launched CORSIA, which comprises a global compensation scheme to reduce CO2 emissions from air transport, establishing as a baseline the number of international flights carried out in each State between 2019 and 2020.

Since the development of air transport infrastructure and the increase in flights can promote economic growth and social inclusion, schemes such as CORSIA may constrain growth strategies in developing countries such as BRICS countries, which need more and sometimes more adequate infrastructure. It is also important to highlight that G7 countries accumulate 30% of the world's RTK while BRICS nations accumulate 17%. Excluding China's percentage from the sum, this number drops to only 5%. Moreover, BRICS countries, primarily members of the ICAO Council, have been implementing several operational measures that increase the efficiency of air transport operations. This increase in efficiency generates a reduction in fuel consumption and, consequently, in CO_2 emissions, as demonstrated in section 3.3, which shows the Total CO_2 Emissions Reduction estimates obtained by the implementation of Operational Measures by Brazil in the year 2021.

6 CONCLUSION AND FUTURE WORK

Tourism is essential for the economic growth of developing countries. To enable the expansion of this activity, however, it is necessary to develop air transport infrastructures that generally have very high costs. As in these countries, there needs to be more infrastructure in several essential sectors, such as health and education, as well as more urgent needs that require immediate government investment; the air transport infrastructure ends up being in the background. BRICS countries are examples of developing countries that can benefit from inbound tourism activities to promote economic growth by expanding their air transport infrastructure. The economic growth process of the BRICS countries would be even more effective if they promote outbound tourism between themselves, encouraged by establishing a preferential visa regime and through cooperation programs for workforce training and technology transfer, among other actions.

Increasing the number of airports in BRICS countries to accommodate more flights and/or rearranging the departure and arrivals from the airports to privilege them, since it is possible allocating direct flights between most of these countries, will not promote economic growth *per se*. Visitors must have favorable conditions to spend resources on goods and services in these countries. Additionally, it is crucial to consider that demand for air transport is associated not only with the accessibility and price of services but also with changes in society's consumption patterns and GDP growth. It is noteworthy that even if consumption patterns change and more people can travel, they could continue to prefer to travel to countries in G7 nations or other destinations in developed countries rather than BRICS and other developing countries.

The change in these preferences may involve adopting policies among the BRICS countries to promote international tourism activities, as well as actions to build human capital and maintain environments conducive to attracting tourists from other BRICS countries and countries around the world. Furthermore, it is necessary to disseminate a more positive image of BRICS countries, highlighting their natural beauties and other attractions. It should be noted, however, the importance of promoting sustainable tourism without generating impacts that degrade the environment and destroy the social fabric, especially in small and more isolated locations.

Market measures such as CORSIA can also mitigate CO2 emissions, considering their global effects. However, they can have a detrimental effect on the growth strategy of developing countries since they restrict the sector's growth in countries with insufficient infrastructure and a much lower number of flights than in developed countries. It is necessary to consider alternative measures to achieve the efficiency of operations and reduction of GHG emissions in these countries through evaluations based on the efficiency of operations and not on the volume of emissions generated. Considering these alternative measures, allowing a sustainable expansion of air transport activities in the BRICS countries will be possible.

In conclusion, there is technical feasibility of creating an air belt of routes to interconnect the BRICS countries and allocating commercial passenger transport flights to promote tourism activities between them to favor their economic development sustainably. For this to happen, it is essential that the governments of the BRICS countries promote public policies to intensify the use of SAF, continue to support the implementation of operational measures to reduce GHG emissions from civil aviation, promote policies that favor the allocation of more international flights between the bloc's countries and encourage tourism activities between these countries. Additionally, publishing a difference in ICAO exempts the bloc's countries from participating in the mandatory CORSIA phase so that they can sustainably expand their air transport infrastructure and the Global South route network.

For future work, it is important to analyze why the population of the BRICS nations are not interested in traveling to other BRICS countries and try to find out ways of promoting international tourism activities inside the arrangement. In Addition, it is important to expand the analysis of the feasibility of creating a Global South Air Transport Belt including the new countries that are joining the BRICS. Finally, with the help of States and airlines, obtaining the actual amount of CO_2 emissions reduction is essential due to the implementation of operational, technological and use of SAF measures and performance management actions.

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ANNEXES

Annex 1 : BRICS countries connections

Table 8 –Brazil – connections. Source : ICAO

STATE B	FLIGHTS	BRAZILIAN FLIGHT CARRIERS	STATE B FLIGHT CARRIERS	OTHER STATES FLIGHT CARRIERS
ARGENTINA	16472	3426	7554	5492
UNITED STATES	14668	3428	8433	2827
PORTUGAL	8705	1213	6763	729
PANAMA	6961	0	6961	0
COLOMBIA	4184	209	3297	678
CHILE	3005	2012	0	993
URUGUAY	3005	2012	0	993
FRANCE	2837	0	2187	650
SPAIN	2610	0	1472	1138
GERMANY	2361	0	1513	848
PERU	2205	53	0	2152
MEXICO	1907	352	877	678
UNITED KINGDOM	1867	0	1180	687
PARAGUAY	1561	460	34	1067
NETHERLANDS	1541	0	1540	1
QATAR	1491	0	1491	0
BOLÍVIA	1327	346	980	1
CANADA	1082	0	1082	0
ITALY	962	0	389	573
EMIRADOS ÁRABES	797	0	797	0
LUXEMBOURG	789	0	539	250
SWITZERLAND	732	0	730	2
ETHIOPIA	519	0	519	0
DOMINICAN REPUBLIC	382	382	0	0
SURINAME	365	164	201	0
ANGOLA	362	0	362	0
ECUADOR	332	64	0	268
GHANA	186	0	0	186
BAHAMAS	178	0	178	0
MALAYSIA	126	0	126	0
GREENLAND	98	0	98	0

VENEZUELA	53	53	0	0
INDONESIA	47	0	42	5
SWEDEN	42	42	0	0
TOGO	33	0	0	33
THAILAND	28	0	28	0
NIGERIA	24	0	0	24
SINGAPORE	21	0	0	21
BELGIUM	16	0	0	16
TURKEY	14	0	14	0
FALKLANDS ISLANDS	8	0	8	0
FRENCH GUIANA	8	0	0	8
SENEGAL	5	0	0	5
VIET NAM	4	0	0	4

Table 9 –Russia – connections. Source: ICAO

STATE B	FLIGHTS	RUSSIAN CARRIES FLIGHTS	STATE B CARRIES FLIGHTS	OTHER STATES FLIGHT CARRIERS
TURKEY	33751	14560	18988	203
UZBEKISTAN	19611	9729	9025	857
TAJIKISTAN	17419	14167	2341	911
UNITED ARAB EMIRATES	16722	2681	10079	3962
KYRZYZTAN	15199	10934	2878	1307
ARMENIA	12491	11140	294	1057
KAZAKHSTAN	11132	6513	4583	36
BELARUS	10121	2959	7156	6
UKRANE	9923	9455	0	468
AZERBAJAN	8335	5412	2714	209
INDIA	6749	289	6321	139
EGYPT	6260	4375	1400	485
CHINA	3244	648	2595	1
GERMANY	2370	1743	389	238
ISRAEL	1849	1104	724	21
QATAR	1763	0	724	1039
SERBIA	1685	160	1501	24
THAILAND	1184	1184	0	0
REPUBLIC OF KOREA	985	228	757	0
OMAN	915	0	38	877
ITALY	907	906	1	0

AUSTRIA	792	226	151	415
NETHERLANDS	787	401	352	34
MALDIVES	728	703	0	25
FINLAND	700	72	628	0
SAUDI ARABIA	640	44	0	596
BAHRAIN	618	0	526	92
KUWAIT	608	0	0	608
HUNGARY	586	308	278	0
SPAIN	545	545	0	0
CYPRUS	543	446	36	61
FRANCE	505	328	177	0
DOMINICAN REPUBLIC	471	394	0	77
REPUBLIC OF MOLDAVA	463	213	192	58
UNITED STATES	457	303	154	0
IRAN	439	189	104	146
SWITZERLAND	437	256	181	0
BELGIUM	402	211	0	191
POLAND	398	90	308	0
GREECE	398	232	105	61
CUBA	383	212	0	171
BULGARIA	364	234	92	38
SRI LANKA	337	283	54	0
UNITED KINGDOM	303	140	59	104
TURKMENISTAN	283	0	248	35
CZECH REPUBLIC	246	166	80	0
LATVIA	221	75	146	0
PAKISTAN	217	217	0	0
CROATIA	215	197	0	18
HONK KONG	214	214	0	0
IRAQ	204	38	164	2
ICELAND	203	203	0	0
SEYCHELLES	196	196	0	0
MEXICO	165	133	0	32
GEORGIA	162	0	162	0
ALGERIA	146	0	146	0
JAPAN	138	116	22	0
ETHIOPIA	121	0	121	0
VIET NAM	111	39	72	0
TUNISIA	109	9	100	0
SLOVENIA	104	104	0	0
AFGHANISTAN	98	0	98	0

SWEDEN	90	86	4	0
SYRIAN ARAB REPUBLIC	89	0	89	0
NORWAY	89	89	0	0
SINGAPORE	81	24	57	0
VENEZUELA	78	7	60	11
PORTUGAL	61	61	0	0
DENMARK	52	52	0	0
ROMANIA	46	46	0	0
BANGLADESH	41	16	0	25
LEBANON	41	41	0	0
MONGOLIA	34	0	34	0
MOROCCO	24	7	17	0
IRELAND	22	22	0	0
JORDAN	19	0	4	15
LAO	18	18	0	0
REPUBLIC OF NORTH MACEDONIA	10	0	0	10
ARGENTINA	1	0	1	0

Table 10 –India– connections. Source: ICAO

STATE B	FLIGHTS	INDIAN CARRIES FLIGHTS	STATE B CARRIES FLIGHTS	OTHER STATES CARRIER FLIGHTS
UNITED ARAB EMIRATES	95239	50141	41212	3886
QATAR	22096	9685	12397	14
SAUDI ARABIA	21229	13102	7988	139
SINGAPORE	19028	7302	11691	35
THAILAND	16859	9188	6949	722
OMAN	14846	6946	7686	214
KUWAIT	12893	5357	7460	76
SRI LANKA	12138	3740	8191	207
UNITED KINGDOM	10140	4304	5664	172
MALAYSIA	9141	883	8254	4
BAHRAIN	8050	1550	6500	0
BANGLADESH	7393	3536	3699	158
RUSSIAN FEDERATION	6749	6321	289	139
MALDIVES	6513	5336	869	308

UNITED STATES OF AMERICA	6479	4006	2473	0
NEPAL	5186	3316	1852	18
HONK KONG	4983	181	3088	1714
GERMANY	4333	1117	3165	51
CHINA	3870	0	3644	226
FRANCE	2858	952	1825	81
ETHIOPIA	2623	0	2623	0
CANADA	2522	1178	1344	0
VIET NAM	2392	357	1868	167
AUSTRALIA	2062	1308	680	74
NETHERLANDS	1858	0	1471	387
JAPAN	1834	369	1468	57
KENYA	1484	348	847	289
IRAQ	978	0	872	106
SWTIZERLAND	879	3	876	0
BHUTAN	832	0	832	0
FINLAND	715	0	715	0
POLAND	555	0	555	0
MAURITIUS	535	0	535	0
IRAN	532	0	532	0
KAZAKHSTAN	502	0	502	0
REPUBLIC OF KOREA	488	150	324	14
MYANMAR	445	141	304	0
EGYPT	443	0	443	0
UZBEKISTAN	382	0	349	33
TAIWAN	313	0	313	0
ISRAEL	291	291	0	0
UNITED REPUBLIC OF TANZANIA	287	0	287	0
AFGHANISTAN	272	84	188	0
KYRGYZSTAN	164	0	16	148
BELGIUM	156	0	0	156
YEMEN	154	0	154	0
IRELAND	128	0	0	128
SEYCHELLES	120	0	120	0
AZERBAIJAN	120	0	120	0
LUXEMBOURG	104	0	0	104
REUNION	92	0	92	0
ITALY	91	0	39	52
TAJIKISTAN	82	0	82	0
TURKEY	81	0	81	0
GEORGIA	68	51	0	17

UKRAINE	65	6	59	0
CAMBODIA	19	0	0	19
JORDAN	17	0	17	0
AUSTRIA	10	0	0	10
MACAO	4	0	0	4
LEBANON	2	0	0	2
INDONESIA	2	0	2	0
FIJI	2	0	0	2
ROMANIA	2	2	0	0
PAKISTAN	1	0	0	1

Table 11 –China– connections. Source: ICAO.

STATE B	FLIGHTS	CHINESE CARRIES FLIGHTS	STATE B CARRIES FLIGHTS	OTHER STATES CARRIER FLIGHTS
UNITED STATES	24170	22121	1341	708
JAPAN	23196	12618	7117	3461
REPUBLIC OF KOREA	18682	3908	7913	6861
HONK KONG	17336	4154	13182	0
THAILAND	12824	8742	1174	2908
TAIWAN	9984	2430	7554	0
CANADA	9053	9052	1	0
PHILIPPINES	7980	4102	1784	2094
VIET NAM	7235	3877	888	2470
MACAO	6664	1632	5032	0
SINGAPORE	6503	4472	1549	482
MALAYSIA	5243	4241	463	539
GERMANY	4657	4046	611	0
ETHIOPIA	4227	2787	1440	0
NETHERLANDS	4058	3939	11	108
FIJI	3947	3947	0	0
INDIA	3870	3644	0	226
BELGIUM	3507	2036	417	1054
MYANMAR	3493	3123	162	208
RUSSIA	3244	2595	648	1
UNITED ARAB EMIRATES	2362	558	1695	109
UNITED KINGDOM	2098	1303	7	788
INDONESIA	2086	1277	800	9
AUSTRALIA	1937	1623	261	53

IRAN	1876	0	1876	0
LUXEMBOURG	1811	432	1379	0
LAO PEOPLE´S DEMOCRATIC REPUBLIC	1607	1377	230	0
AZERBAIJAN	1401	0	1311	90
PAKISTAN	1347	1205	147	0
CAMBODIA	1262	576	686	0
BANGLADESH	1241	723	277	241
ITALY	1138	927	211	0
QATAR	1118	0	1118	0
KAZAKHSTAN	974	61	130	783
NEW ZEALAND	768	352	416	0
FRANCE	749	709	40	0
UZBEKISTAN	687	11	0	676
SPAIN	647	646	0	1
KUWAIT	615	0	615	0
CZECH REPUBLIC	574	572	0	2
SWITZERLAND	538	0	538	0
SRI LANKA	448	272	175	1
KYRGYZSTAN	403	24	0	379
NEPAL	384	322	62	0
FINLAND	378	140	238	0
EGYPT	365	156	209	0
HUNGARY	342	311	0	31
SAUDI ARABIA	286	36	250	0
KENYA	172	88	84	0
MALDIVES	160	160	0	0
DENMARK	149	48	0	101
ISRAEL	146	142	3	1
AUSTRIA	142	49	93	0
POLAND	113	48	65	0
SOUTH AFRICA	94	94	0	0
ALGERIA	61	7	54	0
SERBIA	61	54	7	0
UNITED REPUBLIC OF TANZANIA	58	0	58	0
PORTUGAL	56	56	0	0
BELARUS	54	54	0	0
OMAN	52	0	52	0
BRUNEI	48	0	48	0
GREECE	44	44	0	0
SWEDEN	43	43	0	0

IRAQ	25	5	20	0
GEORGIA	25	0	0	25
TAJIKISTAN	22	18	4	0
DEMOCRATIC REPUBLIC OF CONGO	15	15	0	0
NIGERIA	13	13	0	0
TURKMENISTAN	8	0	8	0
TURKEY	7	6	1	0
SOUTH SUDAN	6	6	0	0
ROMANIA	4	4	0	0
GUINEA	2	2	0	0
SIERRA LEONE	2	2	0	0
COLOMBIA	2	2	0	0
ANGOLA	1	1	0	0

Table 12 –South Africa– connections. Source: ICAO.

STATE B	FLIGHTS	STATE A CARRIES FLIGHTS	STATE B CARRIES FLIGHTS	OTHER STATES CARRIER FLIGHTS
ZIMBABWE	13231	6080	522	6629
ZAMBIA	8176	4901	2006	1269
BOTSWANA	7987	4612	3375	0
NAMIBIA	6358	5384	691	283
MOZAMBIQUE	6205	4898	1552	52
KENYA	4238	0	3467	771
QATAR	3102	0	3102	0
UNITED KINGDOM	3037	28	3009	0
UNITED ARAB EMIRATES	2934	0	2914	20
ETHIOPIA	2380	0	2380	0
REPUBLIC OF KOREA	1950	1950	0	0
GERMANY	1589	0	1589	0
NETHERLANDS	1587	0	1587	0
ANGOLA	1544	444	1100	0
DEMOCRATIC REPUBLIC OF CONGO	1527	1033	0	494
UNITED STATES OF AMERICA	1521	0	1521	0

LESOTHO	1334	1334	0	0
MAURITIUS	1325	462	759	104
UGANDA	974	358	488	128
SWITZERLAND	826	0	826	0
MALAWI	774	0	62	712
FRANCE	749	0	749	0
NIGERIA	740	311	323	106
SINGAPORE	727	0	727	0
RWANDA	724	0	724	0
UNITED REPUBLIC OF TANZANIA	685	585	0	100
AUSTRALIA	532	0	532	0
EGYPT	453	0	453	0
GHANA	312	312	0	0
SEYCHELLES	298	0	298	0
REUNION	220	0	220	0
LUXEMBOURG	216	0	216	0
BELGIUM	191	0	62	129
ISRAEL	157	0	157	0
GABON	147	0	0	147
CHINA	94	0	94	0
CAMEROON	7	0	0	7
TURKEY	5	0	5	0

Annex 2: Direct flights simulations data

Table 13 - Brazil – Russia direct flights data

Departure/Arrival Airports (ICAO)	Reference Code	Flight Time	Total fuel (ton)	Distance (NM)	Average cost (€)
SBGR -UUDD	4E	13:21	85.989	6392	301.300
UUDD - SBGR	4E	14:02	91.420	6392	301.300
SBGR – UUEE	4E	13:19	85.825	6381	301.100
UUEE-SBGR	4E	14:01	91.259	6381	301.100
SBGR - UUWW	4E	13:19	85.669	6372	300.500

UUWW-SBGR	4E	13:59	91.054	6372	300.500
SBGR - UWKD	4C	-	-	-	-
UWKD - SNGR	4C	-	-	-	-
SBGR - URSS	4C	-	-	-	-
URSS - SBGR	4C	-	-	-	-
SBBR - UUDD	4E	12:45	81.262	6072	286.100
UUDD - SBBR	4E	13:21	86.087	6072	286.100
SBBR-UUEE	4E	12:44	81.152	6058	285.700
UUEE - SBBR	4E	13:19	85.720	6058	285.700
SBBR - UUWW	4E	12:43	80.954	6052	285.200
UUWW - SBBR	4E	13:19	85.746	6052	285.200
SBBR-UWKD	4C	-	-	-	-
UWKD - SBBR	4C	-	-	-	-
SBBR - URSS	4C	-	-	-	-
URSS - SBBR	4C	-	-	-	-
SBKP - UUDD	4E	13:21	85.986	6391	301.400
UUDD - SBKP	4E	14:02	91.332	6391	301.400
SBKP - UUEE	4E	13:20	85.822	6381	301.100
UUEE - SBKP	4E	14:01	91.226	6381	301.100
SBKP - UUWW	4E	13:19	85.666	6371	300.600
UUWW - SBKP	4E	13:59	91.037	6371	300.600
SBKP - UWKD	4C	-	-	-	-
UWKD - SBKP	4C	-	-	-	-
SBKP - URSS	4C	-	-	-	-
URSS – SBKP	4C	-	-	-	-
SBCF - UUDD	4E	12:51	81.916	6124	288.700
UUDD - SBCF	4E	13:28	86.910	6124	288.700
SBCF - UUEE	4E	12:49	81.812	6113	288.400
UUEE - SBCF	4E	13:26	86.729	6113	288.400
SBCF - UUWW	4E	12:48	81.656	6103	287.900
UUWW - SBCF	4E	13:25	86.561	6113	288.400
SBCF - UWKD	4C	-	-	-	-
UWKD - SBCF	4C	-	-	-	-
SBCF - URSS	4C	-	-	-	-

URSS - SBCF	4C	-	-	-	-
SBRF - UUDD	4E	11:04	67.750	5265	247.700
UUDD -SBRF	4E	11:40	72.081	5265	247.700
SBRF - UUEE	4E	11:03	67.585	5254	247.500
UUEE - SBRF	4E	11:38	71.879	5254	247.500
SBRF - UUWW	4E	11:02	67.439	5244	246.900
UUWW - SBRF	4E	11:37	71.672	5244	246.900
SBRF - UWKD	4C	-	-	-	-
UWKD - SBRF	4C	-	-	-	-
SBRF - URSS	4C	-	-	-	-
URSS - SBRF	4C	-	-	-	-

Table 14 - Brazil – India direct flights data

Departure/Arrival airports (ICAO)	Reference Code	Flight Time	Total fuel (ton)	Distance (NM)	Average cost (€)
SBGR -VIDP	4E	16;03	108.076	7856	368.000
VIDP - SBGR	4E	-	-	-	-
SBGR – VABB	4E	15:20	101.888	7464	351.500
VABB-SBGR	4E	16:31	112.110	7464	351.500
SBGR – VOBL	4E	15:40	104.713	7644	359.000
VOBL -SBGR	4E	-	-	-	-
SBGR - VOCI	4E	15:34	103.884	7599	352.600
VOCI - SBGR	4E	-	-	-	-
SBGR - VOHS	4E	16:02	107928	7805	364.500
VOHS - SBGR	4E	-	-	-	-
SBBR - VIDP	4E	16:12	109.324	7877	363.700
VIDP - SBBR	4E	-	-	-	-
SBBR-VABB	4E	15:45	105.567	7597	351.500
VABB - SBBR	4E	16:36	112.868	7597	351.500

SBBR - VOBL	4E	16:05	108.471	7800	362.100
VOBL - SBBR	4E	-	-	-	-
SBBR-VOCI	4E	16:00	107.643	7756	356.900
VOCI - SBBR	4E	-	-	-	-
SBBR - VOHS	4E	16:27	111.607	7938	365.800
VOHS - SBBR	4E	-	-	-	-
SBKP - VIDP	4E	16:06	108.561	7887	369.200
VIDP - SBKP	4E	-	-	-	-
SBKP - VABB	4E	15:24	102.406	7500	353.100
VAAB - SBKP	4E	16:36	112.934	7500	353.100
SBKP - VOBL	4E	15:43	105.264	7681	360.800
VOBL - SBKP	4E	-	-	-	-
SBKP - VOCI	4E	15:38	104.448	7636	354.400
VOCI - SBKP	4E	-	-	-	-
SBKP - VOHS	4E	16:06	108.377	7841	366.100
VOHS – SBKP	4E	-	-	-	-
SBCF - VIDP	4E	15:43	105.273	7668	358.000
VIDP - SBCF	4E	-	-	-	-
SBCF - VABB	4E	15:11	100.611	7300	343.200
VABB - SBCF	4E	15:55	107.041	7300	343.200
SBCF - VOBL	4E	15:32	103.559	7503	352.200
VOBL - SBCF	4E	16:26	111.390	7503	352.200
SBCF - VOCI	4E	15:26	102.731	7458	346.300
VOCI - SBCF	4E	16:20	110.580	7458	346.300
SBCF - VOHS	4E	15:53	106.651	7641	356.800
VOHS - SBCF	4E	16:37	113.073	7641	356.800
SBRF - VIDP	4E	14:21	94.025	6985	321.600
VIDP -SBRF	4E	15:31	103.449	6985	321.600
SBRF - VABB	4E	14:00	91.128	6784	310.900
VABB - SBRF	4E	15:00	99.444	6784	310.900
SBRF - VOBL	4E	14:57	98.915	7048	323.300
VOBL - SBRF	4E	15:05	99.785	7048	323.300
SBRF - VOCI	4E	14:51	98.194	7003	319.100
VOCI - SBRF	4E	14:59	99.295	7003	319.100

SBRF - VOHS	4E	14:42	96.884	7125	325.700
VOHS - SBRF	4E	15:43	105.245	7125	325.700

Table 15 - Brazil – China direct flights data

Departure/Arrival airports (ICAO)	Reference Code	Flight Time	Total fuel (ton)	Distance (NM)	Average cost (€)
SBGR -ZBAA	4E	-	-	-	-
ZBAA - SBGR	4E	-	-	-	-
SBGR – ZGGG	4E	-	-	-	-
ZGGG-SBGR	4E	-	-	-	-
SBGR – ZSPD	4E	-	-	-	-
ZSPD -SBGR	4E	-	-	-	-
SBGR - ZSSS	4E	-	-	-	-
ZSSS - SBGR	4E	-	-	-	-
SBGR - ZGSZ	4E	-	-	-	-
ZGSZ - SBGR	4E	-	-	-	-
SBBR - ZBAA	4E	-	-	-	-
ZBAA - SBBR	4E	-	-	-	-
SBBR-ZGGG	4E	-	-	-	-
ZGGG - SBBR	4E	-	-	-	-
SBBR - ZSPD	4E	-	-	-	-
ZSPD - SBBR	4E	-	-	-	-
SBBR-ZSSS	4E	-	-	-	-
ZSSS - SBBR	4E	-	-	-	-
SBBR - ZGSZ	4E	-	-	-	-
ZGSZ - SBBR	4E	-	-	-	-
SBKP - ZBAA	4E	-	-	-	-
ZBAA - SBKP	4E	-	-	-	-
SBKP - ZGGG	4E	-	-	-	-
ZGGG - SBKP	4E	-	-	-	-
SBKP - ZSPD	4E	-	-	-	-

ZSPD - SBKP	4E	-	-	-	-
SBKP - ZSSS	4E	-	-	-	-
SZZZ - SBKP	4E	-	-	-	-
SBKP - ZGSZ	4E	-	-	-	-
ZGSZ – SBKP	4E	-	-	-	-
SBCF - ZBAA	4E	-	-	-	-
ZBAA- SBCF	4E	-	-	-	-
SBCF - ZGGG	4E	-	-	-	-
ZGGG - SBCF	4E	-	-	-	
SBCF - ZSPD	4E	-	-	-	-
ZSPD - SBCF	4E	-	-	-	-
SBCF - ZSSS	4E	-	-	-	-
ZSSS - SBCF	4E	-	-	-	-
SBCF - ZGSZ	4E	-	-	-	-
ZGSZ - SBCF	4E	-	-	-	-
SBRF - ZBAA	4E	-	-	-	-
ZBAA -SBRF	4E	-	-	-	-
SBRF - ZGGG	4E	-	-	-	-
ZGGG - SBRF	4E	-	-	-	-
SBRF - ZSPD	4E	-	-	-	-
ZSPD - SBRF	4E	-	-	-	-
SBRF - ZSSS	4E	-	-	-	-
ZSSS – SBRF	4E	-	-	-	-
SBRF - ZGSZ	4E	-	-	-	-
ZGSZ - SBRF	4E	-	-	-	-

Table 16 - Brazil – South Africa direct flights data

Departure/Arrival airports (ICAO)	Reference Code	Flight Time	Total fuel (ton)	Distance (NM)	Average cost (€)
SBGR -FAOR	4E	07:36	42.214	4079	190.100

FAOR - SBGR	4E	10:46	65.412	4079	190.100
SBGR – FACT	4E	06:42	36.379	3485	162.300
FACT-SBGR	4E	08:55	51.277	3485	162.300
SBGR – FALE	4E	08:15	46.763	4381	194.400
FALE -SBGR	4E	11:16	69.271	4381	194.400
SBGR - FAGG	4C	-	-	-	-
FAGG - SBGR	4C	-	-	-	-
SBGR - FALA	4C	-	-	-	-
FALA - SBGR	4C	-	-	-	-
SBBR - FAOR	4E	08:10	46.206	4333	201.500
FAOR - SBBR	4E	11:12	68.670	4333	201.500
SBBR-FACT	4E	07:20	40.293	3797	176.000
FACT - SBBR	4E	09:37	56.557	3797	176.000
SBBR - FALE	4E	08:45	50.075	4597	207.100
FALE - SBBR	4E	11:37	71.715	4597	207.100
SBBR-FAGG	4C	-	-	-	-
FAGG - SBBR	4C	-	-	-	-
SBBR - FALA	4C	-	-	-	-
FALA - SBBR	4C	-	-	-	-
SBKP - FAOR	4E	07:40	42.689	4115	192.100
FAOR - SBKP	4E	10:51	66.060	4115	192.100
SBKP - FACT	4E	06:46	36.775	3521	164.400
FACT - SBKP	4E	09:01	52.041	3521	164.400
SBKP - FALE	4E	08:19	47.238	4418	196.500
FALE - SBKP	4E	11:22	69.636	4418	196.500
SBKP - FAGG	4C	´-	-	-	-
FAGG - SBKP	4C	-	-	-	-
SBKP - FALA	4C	-	-	-	-
FALA – SBKP	4C	-	-	-	-
SBCF - FAOR	4E	07:36	42.218	4036	187.600
FAOR- SBCF	4E	10:31	63.551	4036	187.600
SBCF - FACT	4E	06:45	36.697	3504	161.400
FACT - SBCF	4E	08:57	51.569	3504	161.400

SBCF - FALE	4E	08:10	46.211	4300	192.900
FALE - SBCF	4E	10:57	66.785	4300	192.900
SBCF - FAGG	4C	-	-	-	-
FAGG - SBCF	4C	-	-	-	-
SBCF - FALA	4C	-	-	-	-
FALA - SBCF	4C	-	-	-	-
SBRF - FAOR	4E	08:55	51.366	4251	177.300
FAOR -SBRF	4E	09:37	56.649	4251	177.300
SBRF - FACT	4E	08:12	46.455	3969	157.600
FACT - SBRF	4E	09:13	53.549	3969	157.600
SBRF - FALE	4E	09:27	55.369	4535	185.300
FALE - SBRF	4E	10:18	61.969	3969	157.600
SBRF - FAGG	4C	-	-	-	-
FAGG – SBRF	4C	-	-	-	-
SBRF – FALA	4C	-	-	-	-
FALA - SBRF	4C	-	-	-	-

Table 17 – Russia - India direct flights data

Departure/Arrival airports (ICAO)	Reference Code	Flight Time	Total fuel (ton)	Distance (NM)	Average cost (€)
UUDD - VIDP	4E	05:12	26.684	2393	110.100
VIDP - UUDD	4E	05:28	28.386	2393	110.100
UUDD – VABB	4E	06:01	31.871	2787	127.500
VABB - UUDD	4E	06:23	34.223	2787	127.500
UUDD – VOBL	4E	06:51	37.371	3195	148.400
VOBL -UUDD	4E	07:15	39.772	3195	148.400
UUDD - VOCI	4E	07:14	39.598	3554	154.500
VOCI - UUDD	4E	07:32	41.727	3554	154.500
UUDD - VOHS	4E	06:31	35.181	3034	139.200
VOHS - UUDD	4E	06:54	37.639	3034	139.200
UUEE - VIDP	4E	05:17	27.237	2435	111.500
VIDP - UUEE	4E	05:34	29.932	2435	111.500

UUEE-VABB	4E	07:20	40.293	3797	176.000
VABB - UUEE	4E	06:06	32.375	3797	176.000
UUEE - VOBL	4E	06:56	37.868	3233	150.000
VOBL - UUEE	4E	07:19	40.169	3233	150.000
UUEE-VOCI	4E	07:17	40.030	3392	156.200
VOCI - UUEE	4E	07:37	42.278	3392	156.200
UUEE - VOHS	4E	06:36	35.678	3072	140.800
VOHS- UUEE	4E	06:57	34.499	3072	140.800
UUWW - VIDP	4E	05:15	26.970	2415	111.200
VIDP - UUWW	4E	05:31	28.695	2415	111.200
UUWW - VABB	4E	06:04	32.160	2808	128.600
VABB - UUWW	4E	06:25	34.511	2808	128.600
UUWW - VOBL	4E	06:54	37.647	3216	149.500
VOBL - UUWW	4E	07:16	39.907	3216	149.500
UUWW - VOCI	4E	07:15	39.669	3375	155.600
VOCI - UUWW	4E	07:35	42.038	3375	155.600
UUWW - VOHS	4E	06:34	35.459	3055	140.400
VOHS – UUWW	4E	06:56	37.927	3055	140.400
UWKD - VIDP	4C	04:55	12.275	2075	95.400
VIDP - UWKD	4C	05:05	12.734	2075	95.400
UWKD - VABB	4C	06:05	15.491	2585	115.400
VABB - UWKD	4C	06:09	15.727	2585	115.400
UWKD - VOBL	4C	07:09	16.352	3002	135.800
VOBL - UWKD	4C	06:57	15.849	3002	135.800
UWKD - VOCI	4C	07:22	16.091	3161	142.600
VOCI - UWKD	4C	07:25	17.028	3161	142.600
UWKD - VOHS	4C	06:25	14.520	2759	125.900
VOHS - UWKD	4C	06:37	15.015	2759	125.900
URSS - VIDP	4C	04:37	11.495	2016	94.300
VIDP -URSS	4C	05:07	12.839	2016	94.300
URSS - VABB	4C	05:10	12.978	2237	104.500
VABB - URSS	4C	05:33	14.027	2237	104.500
URSS - VOBL	4C	06:10	15.787	2692	125.800
VOBL - URSS	4C	-	-	-	-

URSS - VOCI	4C	06:26	16.493	2812	130.400
VOCI – URSS	4C	-	-	-	-
URSS – VOHS	4C	05:52	14.923	2574	118.500
VOHS - URSS	4C	06:19	16.189	2574	118.500

Table 18 – Russia - China direct flights data

Departure/Arrival airports (ICAO)	Reference Code	Flight Time	Total fuel (ton)	Distance (NM)	Average cost (€)
UUDD - ZBAA	4E	06:40	36.197	3176	147.900
ZBAA - UUDD	4E	07:22	40.547	3176	147.900
UUDD – ZGGG	4E	08:11	31.871	2787	127.500
ZZGG - UUDD	4E	08:46	34.223	2787	127.500
UUDD – ZSPD	4E	07:53	44.184	3772	174.700
ZSPD -UUDD	4E	08:38	49.379	3772	174.700
UUDD - ZSSS	4E	07:50	43.834	3747	173.900
ZSSS - UUDD	4E	08:34	49.046	3747	173.900
UUDD - ZGSZ	4E	08:14	46.626	3916	180.800
ZGSZ - UUDD	4E	08:51	50.802	3916	180.800
UUEE - ZBAA	4E	06:42	36.351	3185	148.100
ZBAA - UUEE	4E	05:34	29.932	3185	148.100
UUEE-ZGGG	4E	08:10	46.181	3884	179.000
ZGGG - UUEE	4E	08:47	50.294	3884	179.000
UUEE - ZSPD	4E	07:54	44.336	3781	175.100
ZSPD - UUEE	4E	08:39	49.506	3781	175.100
UUEE-ZSSS	4E	07:51	43.986	3757	174.200
ZSSS - UUEE	4E	07:37	42.278	3757	174.200
UUEE - ZGSZ	4E	08:14	46.644	3921	181.500
ZGSZ- UUEE	4E	08:52	50.874	3921	181.500
UUWW - ZBAA	4E	06:43	36.420	3194	148.700

ZBAA - UUWW	4E	07:24	40.833	3194	148.700
UUWW - ZGGG	4E	08:11	46.314	3893	179.300
ZGGG - UUWW	4E	08:48	50.436	3893	179.300
UUWW - ZSPD	4E	07:55	44.438	3791	175.500
ZSPD - UUWW	4E	08:40	49.664	3791	175.500
UUWW - ZSSS	4E	07:52	44088	3766	174.700
ZSSS - UUWW	4E	08:37	49.312	3766	174.700
UUWW - ZGSZ	4E	08:16	46.836	3930	181.100
ZGSZ – UUWW	4E	08:53	51053	3930	181.100
UWKD - ZBAA	4C	-	-	-	-
ZBAA - UWKD	4C	-	-	-	-
UWKD - ZGGG	4C	-	-	-	-
ZGGG - UWKD	4C	-	-	-	-
UWKD - ZSPD	4C	-	-	-	-
ZSPD - UWKD	4C	-	-	-	-
UWKD - ZSSS	4C	-	-	-	-
ZSSS- UWKD	4C	-	-	-	-
UWKD - ZGSZ	4C	-	-	-	-
ZSGZ - UWKD	4C	-	-	-	-
URSS - ZBAA	4C	-	-	-	-
ZBAA-URSS	4C	-	-	-	-
URSS - ZGGG	4C	-	-	-	-
ZGGG - URSS	4C	-	-	-	-
URSS - ZSPD	4C	-	-	-	-
ZSPD - URSS	4C	-	-	-	-
URSS - ZSSS	4C	-	-	-	-
ZSSS – URSS	4C	-	-	-	-
URSS – ZGSZ	4C	-	-	-	-
ZGSZ - URSS	4C	-	-	-	-

Table 19 – Russia – South Africa direct flights data

Departure/Arrival airports (ICAO)	Reference Code	Flight Time	Total fuel (ton)	Distance (NM)	Average cost (€)
UUDD - FAOR	4E	10:46	65.513	4953	232.900
FAOR - UUDD	4E	10:37	64.314	4953	232.900
UUDD – FACT	4E	12:10	76.130	5549	258.300
FACT - UUDD	4E	11:43	72.524	5549	258.300
UUDD – FALE	4E	11:13	68.817	5174	242.200
FALE -UUDD	4E	11:06	67.926	5174	242.200
UUDD - FAGG	4C	-	-	-	-
FAGG - UUDD	4C	-	-	-	-
UUDD - FALA	4C	-	-	-	-
FALA - UUDD	4C	-	-	-	-
UUEE - FAOR	4E	10:50	66.026	4986	234.400
FAOR - UUEE	4E	10:41	64.805	4986	234.400
UUEE-FACT	4E	12:14	76.692	5581	259.600
FACT - UUEE	4E	11:47	73.058	5581	259.600
UUEE - FALE	4E	11:17	69.339	5206	243.700
FALE - UUEE	4E	11:10	68.416	5206	243.700
UUEE-FAGG	4C	-	-	-	-
FAGG - UUEE	4C	-	-	-	-
UUEE - FALA	4C	-	-	-	-
FALA- UUEE	4C	-	-	-	-
UUWW - FAOR	4E	10:48	65.664	4963	233.300
FAOR - UUWW	4E	10:38	64.461	4963	233.300
UUWW - FACT	4E	12:11	76.337	5559	258.500
FACT - UUWW	4E	11:44	72.681	5559	258.500
UUWW - FALE	4E	11:14	68.986	5183	149.500
FALE - UUWW	4E	11:07	68.072	5183	149.500
UUWW - FAGG	4C	-	-	-	-
FAGG - UUWW	4C	-	-	-	-
UUWW - FALA	4C	-	-	-	-

FALA – UUWW	4C	-	-	-	-
UWKD - FAOR	4C	-	-	-	-
FAOR - UWKD	4C	-	-	-	-
UWKD - FACT	4C	-	-	-	-
FACT - UWKD	4C	-	-	-	-
UWKD - FALE	4C	-	-	-	-
FALE - UWKD	4C	-	-	-	-
UWKD - FAGG	4C	-	-	-	-
FAGG - UWKD	4C	-	-	-	-
UWKD - FALA	4C	-	-	-	-
FALA - UWKD	4C	-	-	-	-
URSS - FAOR	4C	-	-	-	-
FAOR -URSS	4C	-	-	-	-
URSS - FACT	4C	-	-	-	-
FACT - URSS	4C	-	-	-	-
URSS - FALE	4C	-	-	-	-
FALE - URSS	4C	-	-	-	-
URSS - FAGG	4C	-	-	-	-
FAGG – URSS	4C	-	-	-	-
URSS – FALA	4C	-	-	-	-
FALA - URSS	4C	-	-	-	-

Table 20 – India– China direct flights data

Departure/Arrival airports (ICAO)	Reference Code	Flight Time	Total fuel (ton)	Distance (NM)	Average cost (€)
VIDP -ZBAA	4E	05:12	26.705	2406	97.300
ZBAA - VIDP	4E	05:32	28.771	2406	97.300
VIDP – ZGGG	4E	04:33	22.452	2075	93.300
ZGGG-VIDP	4E	04:48	24.015	2075	93.300
VIDP – ZSPD	4E	05:18	34532	2453	109.600
ZSPD -VIDP	4E	05:37	29.382	2453	109.600
VIDP - ZSSS	4E	05:15	27.004	2428	108.500

ZSSS - VIDP	4E	05:34	29.778	2428	108.500
VIDP - ZGSZ	4E	04:37	22.835	2107	95.200
ZGSZ - VIDP	4E	04:52	24.479	2107	95.200
VABB - ZBAA	4E	06:06	32.438	2824	121.800
ZBAA - VABB	4E	06:27	34.693	2824	121.800
VABB-ZGGG	4E	05:03	25.639	2303	107.500
ZGGG - VABB	4E	05:15	26.979	2303	107.500
VABB - ZSPD	4E	06:08	32.660	2819	129.400
ZSPD - VABB	4E	06:23	34.249	2819	129.400
VABB-ZSSS	4E	06:05	32.343	2794	128.300
ZSSS - VABB	4E	06:20	33.904	2794	128.300
VABB - ZGSZ	4E	05:06	26.065	2336	108.900
ZGSZ - SBBR	4E	05:20	27.446	2336	108.900
VOBL - ZBAA	4E	06:14	33.271	2853	123.300
ZBAA - VOBL	4E	06:26	34.574	2853	123.300
VOBL - ZGGG	4E	05:00	25.399	2249	100.00
ZGGG - VOBL	4E	05:04	25.785	2249	100.00
VOBL - ZSPD	4E	06:04	32.181	2772	125.700
ZSPD - VOBL	4E	06:16	33.446	2772	125.700
VOBL - ZSSS	4E	06:01	31.863	2748	124.600
SZZZ - VOBL	4E	06:12	33.102	2748	124.600
VOBL - ZGSZ	4E	05:04	25.773	2277	100.900
ZGSZ – VOBL	4E	05:08	26.182	2277	100.900
VOCI- ZBAA	4E	06:37	35.850	3036	132.000
ZBAA- VOCI	4E	06:48	36.974	3036	132.000
VOCI - ZGGG	4E	05:18	27.227	2386	106.800
ZGGG – VOCI	4E	05:21	27.603	2386	106.800
VOCI - ZSPD	4E	06:27	34.755	2956	133.400
ZSPD – VOCI	4E	06:38	35.872	2956	133.400
VOCI - ZSSS	4E	06:25	34.437	2931	132.300
ZSSS - VOCI	4E	06:35	35.531	2931	132.300
VOCI - ZGSZ	4E	05:17	27.202	2364	107.600
ZGSZ - VOCI	4E	05:16	27.040	2364	107.600
VOHS - ZBAA	4E	05:50	30.662	2662	113.800

ZBAA -VOHS	4E	06:03	32.038	2662	113.800
VOHS - ZGGG	4E	04:34	22.492	2066	94.300
ZGGG - VOHS	4E	04:45	23.690	2066	94.300
VOHS - ZSPD	4E	05:37	29.382	2582	118.300
ZSPD - VOHS	4E	05:53	30.936	2582	118.300
VOHS - ZSSS	4E	05:34	29.065	2557	117.200
ZSSS – VOHS	4E	05:49	30.591	2557	117.200
VOHS - ZGSZ	4E	04:38	22.922	2099	95.500
ZGSZ - VOHS	4E	04:49	24.148	2099	95.500

Table 21 – India– South Africa direct flights data

Departure/Arrival airports (ICAO)	Reference Code	Flight Time	Total fuel (ton)	Distance (NM)	Average cost (€)
VIDP -FAOR	4E	09:46	57.727	4405	204.800
FAOR - VIDP	4E	09:20	54.422	4405	204.800
VIDP – FACT	4E	11:30	70.735	5106	237.300
FACT-VIDP	4E	10:36	64.230	5106	237.300
VIDP – FALE	4E	09:55	58.893	4482	207.100
FALE -VIDP	4E	09:30	55.818	4482	207.100
VIDP - FAGG	4C	-	-	-	-
FAGG - VIDP	4C	-	-	-	-
VIDP - FALA	4C	-	-	-	-
FALA - VIDP	4C	-	-	-	-
VABB - FAOR	4E	08:29	48.327	3753	178.000
FAOR - VABB	4E	08:05	45.523	3753	178.000
VABB-FACT	4E	10:13	61.271	4491	210.400
FACT - VABB	4E	09:20	54.422	4491	210.400
VABB - FALE	4E	08:37	49.287	3867	179.500
FALE - VABB	4E	08:15	46.783	3867	179.500
VABB-FAGG	4C	-	-	-	-
FAGG - VABB	4C	-	-	-	-

VABB - FALA	4C	-	-	-	-
FALA - SBBR	4C	-	-	-	-
VOBL - FAOR	4E	08:38	49.439	3844	176.500
FAOR - VOBL	4E	08:10	46.173	3844	176.500
VOBL - FACT	4E	10:17	61.801	4526	208.300
FACT - VOBL	4E	09:24	55.077	4526	208.300
VOBL - FALE	4E	08:44	49.912	3861	176.300
FALE - VOBL	4E	08:10	46.244	3861	176.300
VOBL - FAGG	4C	-	-	-	-
FAGG - VOBL	4C	-	-	-	-
VOBL - FALA	4C	-	-	-	-
FALA – VOBL	4C	-	-	-	-
VOCI- FAOR	4E	08:14	46.669	3659	168.300
FAOR- VOCI	4E	07:47	43.513	3659	168.300
VOCI - FACT	4E	09:53	58.619	4341	199.900
FACT – VOCI	4E	09:01	52.009	4341	199.900
VOCI - FALE	4E	08:20	47.334	3675	167.700
FALE – VOCI	4E	07:47	43.473	3675	167.700
VOCI - FAGG	4C	-	-	-	-
FAGG - VOCI	4C	-	-	-	-
VOCI - FALA	4C	-	-	-	-
FALA - VOCI	4C	-	-	-	-
VOHS - FAOR	4E	08:56	51.491	4044	185.500
ZBAA -VOHS	4E	08:42	49.614	4044	185.500
VOHS - FACT	4E	10:42	64.932	4745	217.500
FACT - VOHS	4E	09:54	58.793	4745	217.500
VOHS - FALE	4E	09:12	53.421	4105	185.800
FALE - VOHS	4E	08:42	49.740	4745	217.500
VOHS - FAGG	4C	-	-	-	-
FAGG – VOHS	4C	-	-	-	-
VOHS - FALA	4C	-	-	-	-
FALA - VOHS	4C	-	-	-	-

Table 22 – China– South Africa direct flights data

Departure/Arrival airports (ICAO)	Reference Code	Flight Time	Total fuel (ton)	Distance (NM)	Average cost (€)
ZBAA -FAOR	4E	14:17	93.403	6616	299.200
FAOR - ZBAA	4E	13:58	90.854	6616	299.200
ZBAA – FACT	4E	15:59	107.402	7316	331.400
FACT-ZBAA	4E	15:13	100.187	7316	331.400
ZBAA – FALE	4E	14:25	94.617	6656	299.500
FALE -ZBAA	4E	14:01	91.345	6656	299.500
ZBAA - FAGG	4C	-	-	-	-
FAGG - ZBAA	4C	-	-	-	-
ZBAA - FALA	4C	-	-	-	-
FALA - ZBAA	4C	-	-	-	-
ZGGG - FAOR	4E	13:03	83.681	5896	272.700
FAOR -ZGGG	4E	12:20	77.433	5896	272.700
ZGGG-FACT	4E	14:42	97.021	6522	302.700
FACT - ZGGG	4E	13:21	85.995	6522	302.700
ZGGG - FALE	4E	13:01	83.332	5809	270.000
FALE - ZGGG	4E	12:04	75.310	5809	270.000
ZGGG-FAGG	4C	-	-	-	-
FAGG - ZGGG	4C	-	-	-	-
ZGGG - FALA	4C	-	-	-	-
FALA - ZGGG	4C	-	-	-	-
ZSPD - FAOR	4E	14:20	93.907	6542	301.200
FAOR - ZSPD	4E	13:40	88.533	6542	301.200
ZSPD - FACT	4E	16:01	107.798	7168	331.900
FACT - ZSPD	4E	14:39	96.571	7168	331.900
ZSPD - FALE	4E	14:18	93.585	6455	299.300
FALE - ZSPD	4E	13:24	86.482	6455	299.300
ZSPD - FAGG	4C	´-	-	-	-

FAGG - ZSPD	4C	-	-	-	-
ZSPD - FALA	4C	-	-	-	-
FALA – ZSPD	4C	-	-	-	-
ZSSS- FAOR	4E	14:18	93.603	6526	300.200
FAOR- ZSSS	4E	13:38	88.270	6526	300.200
ZSSS - FACT	4E	15:59	107.513	7152	331.000
FACT - ZSSS	4E	14:37	96.291	7152	331.000
ZSSS - FALE	4E	14:15	93.246	6439	298.400
FALE - ZSSS	4E	13:22	86.215	6439	298.400
ZSSS- FAGG	4C	-	-	-	-
FAGG - ZSSS	4C	-	-	-	-
ZSSS - FALA	4C	-	-	-	-
FALA - ZSSS	4C	-	-	-	-
ZGSZ - FAOR	4E	12:59	83.105	5857	273.000
FAOR - ZGSZ	4E	12:15	76.783	5857	273.000
ZGSZ - FACT	4E	14:38	96.375	6483	302.700
FACT - ZGSZ	4E	13:16	85.326	6483	302.700
ZGSZ - FALE	4E	12:56	82.721	5770	270.100
FALE - ZGSZ	4E	11:59	74.672	5770	270.100
ZGSZ - FAGG	4C	-	-	-	-
FAGG – ZGSZ	4C	-	-	-	-
ZGSZ – FALA	4C	-	-	-	-
FALA - ZGSZ	4C	-	-	-	-