Technological entrepreneurship readiness: An analysis across BRICS countries

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Abstract

Technological entrepreneurship presents opportunities for accelerated growth during the Fourth Industrial Revolution and assessing the readiness for such entrepreneurship would be important to investors (interested in profit) and governments (interested in economic growth). The aim of the study was to assess and rank the BRICS (Brazil, Russia, India, China, and South Africa) countries on their level of technological entrepreneurship readiness, so as to direct investor funding or, alternatively, guide government initiatives. Data that was collected in Brazil, Russia, India, China, and South Africa, for the World Values Survey, was used in the study (N=13 895). Mean and composite scores linked to entrepreneurship, as well as the embracement of technology, were compared across countries. These were combined to generate a score used to rank the countries. With each of the individual as well as the composite variables, significant differences were found across the BRICS countries. China was rated the highest on attitudes towards science, while South Africa was rated highest on the openness to entrepreneurship. On the composite score, technology entrepreneurship readiness, China scored the highest. China was ranked as the BRICS country that is most viable for technology entrepreneurship. Technology investors should, thus, consider directing their venture capital eastward. The governments of the other countries should take note of their shortcomings and the results could inform policies to enhance their readiness. The results, at a theoretical level, provided some insights into the conceptualisation of technology-related entrepreneurship.

Keywords: technology, entrepreneurship, readiness, BRICS, investments.

Introduction

Technological entrepreneurship is changing the world's economy and is playing a leading role in several markets. Recent developments in the global economy, in which fourth industrial revolution technologies have disrupted old business models and introduced new ones (Chalmers, Mckenzie, & Carter, 2021; Kruger & Steyn, 2020), have increased the need for more technology-driven entrepreneurship in emerging economies to stay relevant and competitive (Chalmers et al., 2021; Kruger & Steyn, 2020). Venkataraman (2004) posits that technological entrepreneurship could transform a region's economic competitiveness and wealth generation capacity. However, a region's capability to extract such benefits is largely determined by the robustness of its entrepreneurship support environment, which serves as an indicator of its appetite for entrepreneurship in general (Elia, Margherita & Passiante, 2020), as well as the population's readiness for new scientific knowledge and technology (Schwab & Zahidi, 2020).

Technological entrepreneurship is a broad concept and a unique form of entrepreneurship. According to Hemphill (2005), technology entrepreneurship is a sub-dimension of entrepreneurial economic activity. It covers "finding high-value possibilities, assembling the necessary resources to exploit the opportunities, assuming/managing high risks, and rapid growth utilising principled decision-making" for both start-up and established organisations (Venter & Urban, 2015, p.12-13). Its distinctiveness stems from its dependence on scientific ideas and the identification of high-potential, technology-intensive business possibilities for creating and capturing value. Technology entrepreneurs are influential in a wide range of areas in the Unites States of America's economy and they presently drive the United States economy, with companies such as Tesla, Facebook and Amazon investing billions of dollars in artificial intelligence, biotechnology, software and communications (Fukuda, 2020; Knuth, 2018; Rimmer, 2018; Rikap, 2020). Technological entrepreneurs contribute immensely to an economy's international competitiveness through the innovations they generate (Abbas, 2018).

A key factor in the development of technology-driven entrepreneurship is the Fourth Industrial Revolution (4IR), which can be described as a marked technological shift that has transformed how people live, work and interact with each other (Naudé, 2018). Its impact on technological entrepreneurship has been widely discussed in the literature. While some researchers argue that 4IR technologies have the potential to create new business models and entrepreneurial opportunities (Kruger & Steyn, 2020), others suggest that the fast-paced nature of the technological changes associated with the 4IR may also pose significant challenges for entrepreneurs. For instance, in a recent study, Abdullahi, bin Jabor, and Akor (2020) highlight the importance of adaptive entrepreneurial skills and the ability to quickly adjust to changing market conditions, to successfully navigate the complexities of the 4IR landscape. Similarly, Mpofu and Nicolaides (2019) underscore the need to be aware of the ethical implications of emerging technologies and the potential impact of these technologies on society. Overall, the 4IR is reshaping the entrepreneurial landscape, and creating both opportunities and challenges for aspiring entrepreneurs.

The technological revolution driven by technology entrepreneurs, which has resulted in novel technologies such as 3D printing, 5G, nanotechnology, robotics, drones, renewable energy, artificial intelligence, virtual reality, the internet of things, blockchain technology, big data analytics and e-commerce, provides business with opportunities to improve productivity, efficiency, and better ways to compete and create value in markets (Kruger & Steyn, 2020; Schwab & Zahidi, 2020). Firms' performance results over the last two decades suggest that technology-driven entities perform impressively on the NASDAQ and NYSE (Jashari & Jusufi, 2020; Hansda & Ray, 2002). Such firms typically do well because of their capacity to produce fast returns in markets (Zhou, 2007). The success of technology-driven entrepreneurship, as exemplified by the Silicon Valley model, has increased venture capitalists' interests in investing in technology entrepreneurship projects over the years, due to the high potential for economic yields (Audretsch, 2021; Fairlie & Chatterji, 2013; Ibrahim, 2009). According to the United Nation's Conference on Trade and Development (UNCTAD) (2020) Technology and Innovation Report, the disruptive technologies arena "represent a $350-billion market, and one that by 2025 could grow to over $3.2 trillion" (p. 18) and, therefore, presents lucrative opportunities for growth-oriented economies such as those of the BRICS (Brazil, Russia, India, China and South Africa) countries.

Technological entrepreneurship, however, is less common in the less economically developed nations and such communities have not profited greatly from it (Ignatov, 2020; Irene, 2019). Thus, some BRICS countries perform better than others in entrepreneurship. According to the Global Entrepreneurship Development Institute (GEDI) (2022), which measures the quality and dynamics of entrepreneurship across 137 countries based on 14 pillars, China ranked the highest among the BRICS countries in 31st place, followed by Russia in 41st, South Africa in 49th, Brazil in 59th, and India in 63rd place. There is a perception that support for start-up technopreneurs, from the different entrepreneurial ecosystem actors (government, venture capitalists and support services providers, among others), in emerging countries is insufficient, which is used as an explanation for slow growth (Lowe, 2016; Shabrina, Santoso & Alfanisa, 2019). According to UNCTAD (2020), the potential for frontier technology-related economic activity, in less developed countries, is limited by lower technology and innovation capacities, weak research and development financing mechanisms, and strict intellectual property rights and technology transfer restrictions imposed by developed countries.

With BRICS countries mainly having developing economies, citizens and countries must show that they are receptive to technology-driven entrepreneurship to potential funders. Unlike in industrialised economies where empirical data on technological entrepreneurship preparedness is readily available (Yeganegi, Laplume & Dass, 2021), it is less so in emerging economies. As a result, only a limited understanding of how much technology entrepreneurship is practised or anticipated in BRICS is available. This leaves a hole in the knowledge base, which this study tries to fill. The study results will afford researchers, governments and other interested economic actors the opportunity to gain a more nuanced understanding of the scope and readiness of different geographical areas for technology-related entrepreneurship. Considering this background, the primary purpose of the present study is to evaluate the extent of technological entrepreneurship readiness in BRICS countries and how it varies across the bloc's members, using the World Values Survey (Wave 6) data.

BRICS countries were selected over other emerging countries as they are aligned by treaties (Garcia, 2017), their comparable development trends and they have the potential to become a major economic bloc outside of the G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom and the United States). It is forecasted that by 2050, the economies of these nations are predicted to outperform those of the G7 countries (Kwenda, 2018).

The remainder of this paper is divided into four sections. First, the existing literature on the subject is examined. This is followed by a description of the study's research design and methods. The study's results are then presented and analysed. Thereafter, the paper concludes with a discussion of the theoretical and practical implications, as well as future research areas.

Literature review

An overview of the BRICS

The BRICS (Brazil, Russia, India, China and South Africa) are a collection of countries that span three continents. The group was founded in 2009 as BRIC, but was renamed BRICS in 2011 after the addition of South Africa (Cooper, 2016). The bloc came together because of several factors, including economic liberalisation and the need to protect countries' sovereign rights around the world (Prabhakar, 2011). Goldman Sachs originated the term after predicting that by 2050, these countries' economies would jointly beat the G7. The G7 countries have a total population of about 0.8 billion and the countries have controlled 27% of global GDP and 15% of global GDP growth between 2012 and 2022 (World Economics, 2023). The BRICS countries hoped to use their large population (43% of the global population) and economic clout (controlling 18% of global trade and 20% of global gross domestic income, 55% in purchasing power; treble growth in foreign direct investment in the countries) as a delicate defensive shield against US geopolitical hegemony, while also ensuring multipolarity (Makin & Arora, 2014). The remarkable growth of the Chinese economy has made it a significant player in global politics and soft power, challenging the traditional dominance of the G7 countries in the global order.

According to Laidi (2012), despite this, the bloc has remained relatively weak as its members have been overly focused on narrow national interests and a general climate of suspicion exists between some members (China against Russia) due to historical reasons. China has also emerged as the grouping's single most prominent partner due to its population size, military force, economic weight, international influence, worldwide presence and involvement. According to Thakur (2014), the bloc's goals are complicated by the members' diverse interests, values and policy preferences. Moreover, concerns have been raised about the group's ability to simultaneously promote its own economic interests and those of developing countries. Despite the challenges that the BRICS countries face, and the fact that economic dominance is not guaranteed for them unless they implement drastic economic policies (Cheng, Gutierrez, Mahajan, Shachmurove & Shahrokhi, 2007), their current and future impacts on the global economy cannot be overlooked. This necessitates a further study of socio-economic activity in the bloc to reach a better understanding. Table 1 provides an overview of some key statistics relating to the BRICS countries' economic, social, science and technological situation. Further details are provided in the subsequent sections.

Table 1: BRICS countries compared on population size, GDP, R&D spend and ratings on ease of doing business and technology readiness

Country	% of world population[a]	GDP per capita[b]	% R&D spend per GDP[c]	Ease of doing business global ranking[d]	Frontier technologies readiness index[e] (and ranking [f]
Brazil	2.7%	8 754	1.3%	124	0.65 (41)
Russia	1.9%	11 584	1.0%	29	0.75 (27)
India	17.3%	2 054	0.7%	62	0.62 (43)
China	18.3%	10 276	2.2%	32	0.88 (15)
South Africa	0.8%	5 979	0.8%	84	0.55 (54)

a. Share of world population in 2019 (BRICS Region statistics booklet, 2020)
b. Per capita Gross Domestic Product in US dollar terms in 2019 (BRICS Region statistics booklet, 2020)
c. Research and development spend to GDP in 2019 (BRICS Region statistics booklet, 2020)
d. Ease of doing business global ranking in 2018 (The World Bank, 2018)
e. Frontier technologies readiness index (where 1 is the highest score) in 2020 (UNCTAD technology report, 2020)
f. Country ranking on frontier technologies readiness in 2020 (UNCTAD technology report, 2020)

The present literature, thus, suggests that the BRICS configuration is skewed in terms of population, with India and China being much more populated than any of the other countries. GDP per capita is skewed towards China and Russia. When considering the size of the economies (based on the product of population proportion and GDP per capita), the Chinese economy is the largest. Given this crude measure, the score for China is 188 050.8 (18.3 x 10 276), followed by India 35 534.2 (17.3 x 2 054), then Brazil 23635.8, Russia 22009.6 (1.9 x 11584) and South Africa 4783.2 (0.8 x 5979). In terms of R&D spend per GDP and technologies readiness, China outperforms all the other BRICS countries. Russia scores best on ease of doing business, with China in the second place, and South Africa and Brazil taking up fourth and fifth places, respectively.

Technology entrepreneurship (technopreneurship) and its practice in the BRICS

Understanding technology entrepreneurship (technopreneurship)

In the literature, the terms "technology entrepreneurship", "technopreneurship", "digital entrepreneurship" and "digital technology entrepreneurship" have all been used interchangeably. There are terminologies used to characterise entrepreneurship that are tied to scientific and technological innovations. Beckman, Eisenhardt, Kotha, Meyer and Rajagopalan (2012), for example, distinguish technological entrepreneurship from conventional entrepreneurship by underlining its emphasis on the development, discovery and pursuit of economic opportunities, made feasible by scientific and technology advances. Likewise, Bailetti (2012) defines technology entrepreneurship as "an investment in a project that assembles and deploys specialised individuals and heterogeneous assets for the purpose of creating value for a firm that is intricately related to advances in scientific and technological knowledge for the purpose of creating value for a firm that is intricately related to advances in scientific and technological knowledge" (p. 9). Lastly, Mosey, Guerrero and Greenman (2017) characterise technology entrepreneurship as individuals or organisations identifying and chasing technological opportunities through the establishment of new companies. For the present study, technology entrepreneurship is described as the creation, discovery and exploitation of a market opportunity whose end-product is the development of a business, market or industry, with scientific and technological know-how supporting it.

There are contrasting perspectives on technological entrepreneurship, with some researchers arguing that it is a critical driver of economic growth and innovation, while others suggest that it may contribute to social and economic inequality. Proponents of technological entrepreneurship argue that it creates new business opportunities, fosters innovation and improves productivity. According to this perspective, technological entrepreneurship helps to develop new products and services, increases efficiency and creates new job opportunities, leading to economic growth and development (Evers et al., 2020; Jafari-Sadeghi et al., 2021; Urbano et al., 2019).

On the other hand, critics argue that technological entrepreneurship can lead to the concentration of wealth and power in the hands of a few, contributing to social and economic inequality (Kuschel et al., 2020; Broockman et al., 2019). According to this perspective, technological entrepreneurship may result in the displacement of workers, the erosion of job security and the exploitation of consumers, leading to negative social and economic outcomes (Arocena & Senker, 2003; Bruton et al., 2021). Furthermore, some researchers argue that technological entrepreneurship may also have negative environmental impacts. For example, the increasing use of technology may lead to higher energy consumption and increased carbon emissions, contributing to climate change (Cohen & Winn, 2007; Dean & McMullen, 2007). Although technological entrepreneurship has the potential to drive economic growth and innovation, it is important to consider its potential social, economic and environmental impacts. Policymakers and entrepreneurs need to carefully consider the potential consequences of technological entrepreneurship and take steps to mitigate negative impacts, while promoting the positive ones.

Technopreneurship is credited with boosting economic activity in industrialised nations and comparable evidence has been found in some of the BRICS countries (Ignatov, 2020; Lazanyuk & Revinova, 2019; Popkova, Inshakova & Sergi, 2021). Considering this, it has become increasingly difficult to underestimate the importance of technology entrepreneurship as a source of economic growth, and its ability to effect deep and long-term societal changes (Beckman et al., 2012). In the next subsections, an outline of technopreneurship in the BRICS economic group is provided.

Technology entrepreneurship in Brazil

The importance of technology entrepreneurship in the Brazilian economy is demonstrated by scholarly literature on the subject. For example, Marques, de Oliviera, Andrade and Zambalde (2019) explain how all federal institutions in the state of Minas Gerais have invested in technological innovation centres to help the commercialisation of ideas. Moreover, given the high degree of internet connectivity and big number of tech-savvy customers in the country, the country is an essential investment location for high-tech enterprises (Stanford University, n.d.). Siluk, Garlet, Marcuzzo, Michelin and Minello (2018), on the other hand, suggest that technology-based investments in Brazil are unrelated to the country's GDP and Human Development Index. According to the researchers, the country's technopreneurs move into areas where both local and international demand is very low, and their approaches are built on copying worldwide success stories without paying enough attention to local market quirks. Furthermore, the country's technological enterprises are hampered by a lack of resources and a high level of informality.

Technology entrepreneurship in Russia

Russia is a central player on the global arena with the country having one of the world's biggest economies (after USA and China) and a GDP (current US$) of $1.687 trillion in 2019 (World Bank, 2021). Its transition from a centrally planned economy, since 1989, saw an increase in the number of technology-based entrepreneurial firms in the country (Bruton & Rubanik, 1997). These ventures rode on the country's strength as a historical source technological innovation. Its path towards technology was reinforced by the country's then Prime Minister's "Go Russia" programme, which outlined Russia's national technopreneurship agenda (OC&C Strategy Consultants, 2018). Despite the country's lofty goal of modernising its economy, foreign investments in the country's technology sector have been hampered by the country's historical culture of over-regulation and secrecy (e.g., IBM's abandonment of manufacturing in Russia) (Banerjee, 1996). As a result, investors are wary of the country's risk and technology entrepreneurs' access to capital is restricted. According to OC&C Strategy Consultants (2018), Russia's technology entrepreneurship ecosystem is behind that of advanced European economies, with room for improvement in "start-up density, entrepreneurial growth aspirations, job creation expectations, and contribution of the knowledge sectors to the economy" (p. 20).

Technology entrepreneurship in India

India is ranked 77th out 190 countries on the Ease of Doing Business Index in 2019 (World Bank, 2022). Although the Global Entrepreneurship Monitor (2021) reports that India's total early-stage entrepreneurial activity (TEA) declined drastically from 15% in 2019 to 5.3% in 2020 for an unknown reason, the country's largely entrepreneurial economy is technologically strong and well-connected to the global economy, making it a conducive destination for technology entrepreneurs. In 2015, its IT industry accrued revenues of US $145 billion, the IT services sector accumulated US $40 billion, and engineering, research and development services exported US $10 billion worth of services in the same year (Meil & Salzman, 2017). Khan and Khumar (2019) contend that India's automotive sector is suitable to technopreneurship because of growing demand for technology products, strong legislative support, a conducive infrastructure and considerable investments in the country. Moreover, India's ambitious science, technology and innovation agenda also fosters technology entrepreneurship by aiming to increase the country's knowledge networks, infrastructure and commercial investment (Tripathi & Brahma, 2018).

Technology entrepreneurship in China

China is the most powerful actor in the global economy among the BRICS countries. In 2021, the country accounted for 18% of world GDP (National Bureau of Statistics, 2021), closing the gap on the United States. Despite the country's central planning economy, entrepreneurship is a popular career choice among the country's young and educated, particularly with entrepreneurs returning from economically advanced countries to start technological businesses (Ahlstrom & Ding, 2014). Entrepreneurship gained popularity in the country from 1978, following the adaptation of the "Reform and Opening-Up" policies in 1978 (He, Lu & Qian, 2019). Technology entrepreneurship in China is spurred by the country's policy to incentivise the establishment of technology-oriented enterprises in specified sites, such as research parks and technology business incubators (Yu, Stough & Nijkamp, 2009). Notably, foreign investors are funding scientific parks and technological incubators

(Chien & Gordon, 2008). Such businesses, through producing export-oriented commodities, drive China's competitiveness in the global economy. According to Zhang, Peng and Li (2008), there are regional variances in technological entrepreneurial activity across the country, which they attribute to various economic policies in different provinces.

Technology entrepreneurship in South Africa

According to the World Bank (2021), South Africa's economy ranks third on the African continent, behind Nigeria and Egypt, with a nominal GDP of US $329.6 billion. However, its GDP per capita is 77% lower than that of the Organisation for Economic Cooperation and Development (OECD)'s top performers (OECD, 2021). The country has the most advanced economy on the African continent, with several high-tech firms controlled by both domestic and foreign investors. Historically, however, rates of technological entrepreneurship in South Africa have varied, reflecting the uneven distribution of technology (Koekemoer & Kachieng'a, 2002). Cities and industrialised areas have a high concentration of technological entrepreneurship, with some of these cities having world-class technology and innovation clusters. The drive for technological entrepreneurship is part of the country's National Development Plan, which aims to raise the living conditions of ordinary people (OC&C Strategy Consultants, 2018). According to OC&C Strategy Consultants, South Africa's technological entrepreneurship environment is robust and superior to that of many other emerging economies, due to significant government support and several initiatives aimed at encouraging technology entrepreneurship.

South Africa's entrepreneurship development strategy is focused on creating an enabling environment for entrepreneurship through policy and institutional support, funding programmes and incentives, and incubation and acceleration programmes. One of the key strategies is the National Development Plan (NDP), which identifies entrepreneurship as a critical driver of economic growth and job creation. The NDP outlines specific goals and targets for promoting entrepreneurship, including increasing the number of new business start-ups and reducing the failure rate of new businesses. In addition to the NDP, the South African government has established various institutions and initiatives to support entrepreneurship. For example, the Small Enterprise Development Agency (SEDA) provides business development services and support to small and medium-sized enterprises (SMEs), while the National Youth Development Agency (NYDA) focuses on supporting youth entrepreneurship. The government has also implemented various funding programmes and incentives to support entrepreneurial activity, including tax incentives for small businesses, funding for research and development, and grants and loans for SMEs. Lastly, South Africa has established various incubation and acceleration programmes to support the growth and development of start-ups. For example, the Technology Innovation Agency (TIA) provides funding and support to technology start-ups, while the Innovation Hub is a science and technology park that provides incubation and acceleration services to innovative start-ups. While there have been some successes, challenges, such as access to funding, lack of skills and limited access to markets, still remain and require continuous effort and improvement.

Contribution of attitude to science and technology/technology readiness

The target population's attitude towards science and technology to technology readiness were linked in this study. The term "technology readiness" is used in the literature to characterise a person's willingness to adopt new science and technology (Blut & Wung, 2018). It is the culmination of a series of mental processes that result in the establishment of negative or positive attitudes about science and technology matters (Parasuraman & Colby, 2015). Overall, technological readiness is a changing trait-like feature shaped by a scenario that separates people, depending on their predisposition to engage with science and technology.

Although the term "technology readiness" is extensively used, researchers dispute over its dimensionality, with some claiming it is a unidimensional factor and others suggesting it is multidimensional. Some researchers have employed numerous indicators to create a single technological readiness index that disregards the proportionate contributions of the many components to the whole (Vize, Coughlan, Kennedy & Ellis-Chadwick, 2013).

Alternatively, Parasuraman and Colby (2015) regard technological readiness as comprising four components, namely, optimism (a positive attitude towards technology and benefits), innovativeness (an inclination to initiate and adopt new technology), discomfort (sense of uneasiness and anxiety with using technology) and insecurity (lack of trust in technology, often emanating from fear of potentially negative consequences, which may result from using technology). Blut and Wang (2018) elect to reduce the dimensions identified by Parasuraman and Colby into two dimensions i.e., enablers (innovativeness and optimism) and inhibitors (discomfort and insecurity).

Technology readiness is economically significant since it indicates a society's potential as an investment destination for technology-driven ventures, as well as a prospective market for cutting-edge technology products (Kayalvizhi & Thenmozhi, 2018; Popovici & Călin, 2015). The World Economic Forum considers the technology readiness index to be a key factor in assessing a country's or regions national competitiveness. The aim of the study was to contribute to the literature by examining the condition of technological readiness from a values standpoint. The uniqueness of this approach is that a value systems-driven analysis of society's attitudes towards science and technology provides insightful information into what motivates various feelings towards technology-related issues, such as technopreneurship and artificial intelligence. Furthermore, such research yields insights that can be used to segment consumers of science and technology-related products into sub-markets based on common values. According to Cormick and Romanach (2014), such a customer categorisation provides more nuanced insight into forecasts of different people's attitudes towards economic activities related to frontier technologies than other socio-economic indices provided by government departments, economic think-tanks or global bodies.

Openness to entrepreneurship

The importance of greater entrepreneurial activity in any region cannot be overstated. Entrepreneurs have long been recognised as economic change agents capable of introducing innovations that drive economic growth and social development in an area through creative destruction (Spencer & Kirchhoff, 2006). The openness to entrepreneurship factor is an important component in the development of entrepreneurial activity in an area, since it increases their ability to see possibilities (Antoncic, Antoncic, Grum & Ruzzier, 2018). In this study, the term referred to the receptivity of a nation's inhabitants to enterprise issues. Numerous earlier studies, from a psychological standpoint, have verified the favourable relationship between having an openness to change attribute and being responsive to entrepreneurship (Santoro, Quaglia, Pellicelli & De Bernardi, 2020; Hachana, Berraies & Ftiti, 2018; Dai, Li & Zhang, 2019; Wood, 2012). Other scholars have also provided evidence on how the openness trait in individuals factor has influenced regional variations in entrepreneurship rates (Obschonka, Lee, Rodríguez-Pose, Eichstaedt & Ebert, 2020). From a values perspective, Liñán, Moriano and Jaén (2016) postulate that openness to change values are integral to entrepreneurial activity. Although the link between the openness factor and entrepreneurship activity is acknowledged in the literature, this body of scholarly work is still emerging and has unexplored areas. In this study, a methodological contribution is provided by investigating this link using a values-based dataset from the World Values Survey on the BRICS countries. According to preliminary information, the five countries differ in their desire for entrepreneurship as well as their entrepreneurial performance. For example, the entrepreneurship development rankings in the five nations based on the 2018 global entrepreneurship index are as follows: China=43, South Africa=58, India=68, Russia=78 and Brazil=98 (Global Entrepreneurship Development Institute, 2022), where a lower value suggests a better performance.

Method

In this section, the study's design, procedure, measurement instruments used, appropriate statistical techniques and ethical considerations are all explained.

Design

This study is based on data obtained from the interviews conducted by the World Values Survey (WVS) Wave 6 in Brazil, Russia, India, China and South Africa (BRICS). The data used was cross-sectional data. Only numerical information was examined. The study's main goal of the analysis was to perform an inter-country comparison of the respondents' openness to entrepreneurship and the respondents' attitudes to science and technology, which when combined, could act as a proxy for technological entrepreneurship readiness in the respective countries.

Measurement

a) *Openness to entrepreneurship (OtE)*: Items V96, V98 and V99 on the WVS (6th Wave) were used to measure the variable. Participants were requested to respond to three ipsative questions. The preamble to the questions read as follows: "How would you place your views on this scale? 1 means you agree completely with the statement on the left; 10 means you agree completely with the statement on the right; and if your views fall somewhere in between, you can choose any number in between". Presented below, are the three competing questions:

- V96: Incomes should be made more equal – we need larger income differences as incentives for individual effort.
- V98: The government should take more responsibility to ensure that everyone is provided for – people should take more responsibility to provide for themselves.
- V99: Competition is good. It stimulates people to work hard and develop new ideas – competition is harmful. It brings out the worst in people.

It can be observed, from the above, that for each indicator item, respondents had to make forced choices or show a preference for one of two seemingly desirable options. V99 was recoded, as a higher score there represented an un-entrepreneurial attitude. A composite score was calculated to capture this concept, with the process as discussed in the procedure section, and this composite variable was called "Openness to entrepreneurship".

b) *Attitude towards science and technology (AtST)*: This variable was measured using items V192, V193 and V197, which were presented in Likert scale form. Respondents were required to indicate how much they agreed or disagreed with the list of statements. For these questions, as per the WVS code book, 1 means that you completely disagree and 10 means you completely agree with the statement.

- V192: Science and technology are making our lives healthier, easier and more comfortable.
- V193: Because of science and technology, there will more opportunities for the next generation.

- V197: The world is better off or worse off, because of science and technology.

From the above, it is clear if the latent variable measured by the items above is a positive attitude towards science and technology. A composite score was calculated to capture attitude towards science and technology, as discussed in the procedure section, and this variable was called "Attitude towards science and technology".

Procedure

Since the aim of the study was to conduct an inter-country comparison on the BRICS countries data, mean scores on the different variables were presented, as well as tests of the difference of means, viz analysis of variance (ANOVA) and post-hoc tests. Questionnaire items V192, V193 and V197 were combined to create a composite score for attitude to science and technology; V96, V98 and V99 (reverse coded) were combined to create the composite score for openness to entrepreneurship. It was argued, from wording of the items, that the composite scores would be a more comprehensive representation of the constructs than the individual items. Composite scores were created by weighting all items with 1, which was acceptable given that the range of all items was between 1 and 10. This composite score, where items are weighted by 1, was proven as an extremely effective strategy across contexts (Bobco, Roth & Buster, 2007), and endorsed by the respectable authors, Cascio and Aguinis (2011).

Apart from the two composites scores created for openness to entrepreneurship and attitude towards science and technology, a grand score was also calculated, again following the example of Bobco et al. (2007), where openness to entrepreneurship and attitude towards science and technology were combined to create a "technological entrepreneurship readiness" (TER) variable.

All analyses were performed in Statistical Package for the Social Sciences (SPSS) 28 (IBM Corp, 2021). As the sample size is relatively large (N=13895), statistical significance was assumed when p-values were smaller than .001. Practical significances were also determined following the eta-squared effect size criteria. The rule-of-thumb for interpreting eta-squared is 0.01=small effect size; 0.06=medium effect size and 0.14=large effect size.

Results

The results from the study are presented as follows. First, the demographic details of the respondents are presented. The descriptive statistics for the individual items as well as the composite scores, openness to entrepreneurship, attitudes to science and technology, and technological entrepreneurship readiness then follow. The section closes with the results pertaining to cross-country differences on the composite scores (ANOVA's) and post-hoc tests.

Demographics

In total, 12656 responses were collected. The numbers of respondents per country are presented in the second row of Table 2.

In Table 2, the samples size as well as the sex and age of the respondents are presented. In terms of gender, women comprised most respondents for Brazil, Russia, China and South Africa, while men were the majority for India. The mean ages of the respondents ranged from 36 years to 46 years, with South Africa having the youngest set of respondents and Russia, the oldest.

Table 2: Sex and age across BRICS, express as percentage of the sample

	Brazil	Russia	India	China	South Africa
N	1486	2500	4075	2300	3531
Sex (% men)	37.6	44.6	56.2	49	49.96
Sex (% women)	62.4	55.4	43.8	51	50.04
Age (mean) in years	42.82	46.06	41.24	43.92	36.67
Age std deviation	16.37	17.42	14.53	14.95	14.14

Source: Author's own work

A wide variety of ethnic groups are reported across the BRICS countries and, for this reason, only the major groups will be mentioned here. In Brazil, 47.2% identified as "White/Caucasian White", 39.8% as "Mixed race" and 12.3% as "Black". In Russia, all participants identified as "White/Caucasian White". With India, 19.7% of the respondents identified "Indian - Scheduled Castes", 6.6% as "Indian - Scheduled Tribus", with the largest group being identified as "Indian - Other Backward Castes" (39.9%). The "Other" group in India was relatively large (32.1%), which suggests large diversity in the Indian sample. In China, all respondents identified as "Asian - East (Chinese, Japanese)". In South Africa, the dominant groups were "Black" at 76.5%, followed by "White" at 12.1% and "Coloured" with 8.7%.

These results suggest homogeneity across Russia and China, and much larger levels of diversity in Brazil, India and South Africa. It is well known that Russia and China are both ethnically diverse, maybe even more so than the other countries on this list; this data will not be interpreted, but is rather presented here as an interesting feature of the WVS.

In Table 3, the highest level of education obtained, across BRICS countries, is presented.

Table 3: Highest level of formal education in BRICS, express as percentage of the sample

Level of schooling	Brazil	Russia	India	China	South Africa
None	.6%	.1%	24.9%	7.6%	2.4%
Incomplete primary schooling	31.8%	.3%	9.4%	-	4.4%
Complete primary schooling	12.2%	1.4%	11.8%	23.2%	6.1%
Incomplete secondary schooling	9.9%	12.9%	16.1%	-	44.3%
Complete secondary schooling	28.5%	54.1%	24.4%	52.3%	30.5%
University education without degree	6.5%	5.3%	2.7%	-	4.8%
University education with degree	10.1%	26%	10.6%	16.9%	4.2%

Source: Author's own work

From Table 3, it can be observed that for all the five countries, most respondents completed primary schooling and can be inferred to have had reasonable levels of literacy.

Mean scores and standard deviations for the different items, as well as the three composite scores are presented below.

Table 4: Mean scores, and the standard deviations for OtE, AtST and TER

		Brazil N=1388	Russia N=2188	India N=3435	China N=2114	South Africa N=3392
V96	Mean	5.07	3.35	2.92	4.45	6.05
	SD	3.40	2.57	2.44	2.74	2.74
V98	Mean	4.01	3.11	3.36	4.65	5.77
	SD	3.17	2.61	2.80	2.65	2.69
V99	Mean	3.74	4.36	2.73	3.67	5.21
	SD	2.96	2.68	2.43	2.09	2.72
OtE	Mean	15.33	12.12	13.58	15.44	16.6
	SD	5.38	4.82	12.12	4.76	4.95
V192	Mean	7.01	7.77	7.46	8.33	7.39
	SD	2.838	2.212	2.10	1.69	1.97
V193	Mean	7.58	8.18	7.49	8.16	7.29
	SD	2.63	2.06	2.13	1.80	2.01
V197	Mean	6.31	7.75	6.90	8.33	7.08
	SD	3.028	2.049	2.29	1.410	2.09
AtST	Mean	20.81	23.88	21.85	24.82	21.84
	SD	6.47	5.32	5.49	4.22	4.70
TER	Mean	36.15	36.20	35.67	40.34	38.44
	SD	8.90	7.01	6.970	6.80	7.03

Note: OtE = Openness to entrepreneurship; AtST = Attitude towards science and technology; TER = Technological entrepreneurship readiness

Source: Author's own work

Inspection of Table 4 reveals that differences between mean scores across countries are likely. A one-way ANOVA between subjects' tests was conducted to compare the three composite scores. The results are summarised in Table 5.

Table 5: ANOVA test results (Composite scores only)

		Sum of Squares	df	Mean Square	F	Sig.
OtE	Between Groups	33151.65	4	8 287.91	379.22	<.000
	Within Groups	273446.52	12 512	21.85	-	-
	Total	306598.18	12 516	-	-	-
AtST	Between Groups	20861.58	4	5 215.39	191.19	<.001
	Within Groups	346571.86	12 705	27.27	-	-
	Total	367433.45	12 709	-	-	-
TER	Between Groups	33576.72	4	8 394.18	161.03	<.001
	Within Groups	609423.11	11 691	52.12	-	-
	Total	642999.84	11 695	-	-	-

Note: OtE = Openness to entrepreneurship; AtST = Attitude towards science and technology; TER = Technological entrepreneurship readiness

Source: Author's own work

Differences occur across mean scores, on all three composite scores, as per the ANOVA results. While assumptions on where these differences may occur can be made from Table 3, this could be tested statistically and, as such, post-hoc comparisons using the Tukey HSD test were applied. These results are not presented here but may be obtained from the first author. In sum, the Tukey HSD test revealed that on openness to entrepreneurship, the scores were different across the countries, except for Brazil and China, where the openness to entrepreneurship scores were very similar, with a mean difference -.109 (p-value .961). The result of the post-hoc test for attitude towards science and technology revealed that differences among countries were across the board. Lastly, Table 4 also shows that the technological entrepreneurship readiness scores were also significantly different. An eta-squared effect size value of .052 was derived for this difference, suggesting a moderate effect size for the relationship between the variables. The post-hoc comparisons using the Tukey HSD test demonstrates that the mean score differences were not significant between the following countries: Brazil and India, as well as India and Russia.

The homogeneous subsets statistics are very useful from the SPSS outputs, which orders mean scores according to levels of similarity. These results for the technological entrepreneurship readiness variable are summarised in Table 6. From Table 5, India, Brazil and Russia fall in the same and lowest score category of technology entrepreneurship readiness based on mean scores. China is ranked with the highest score on this variable, followed by South Africa.

Table 6: Mean scores homogeneous subsets for technological entrepreneurship readiness

Country	Group 1	Group 2	Group 3
India (N=3 386)	35.67	-	-
Brazil (N=1 329)	36.15	-	-
Russia (N=1 971)	36.20	-	-
South Africa (N=3 263)	-	38.44	-
China (N=1 747)	-	-	40.34
Sig.	.125	1.000	1.000

Note: Means for groups in homogeneous subsets are displayed. The group sizes are unequal. The harmonic mean of the group sizes is used. The harmonic mean sample size = 2 054.22. Type I error levels are not guaranteed.

Source: Author's own work

Discussion of results

The high expectations for BRICS countries' future contributions to the global economy have prompted academics and other stakeholders to focus on the probable causes of this economic rise. Rather than relying just on statistics from economic development organisations to judge these countries' economic prospects, more nuanced information can be acquired by using values-based empirical data on people's attitudes toward and impressions of economic realities. This study examines the five countries' openness to entrepreneurship, and attitudes towards science and technology using WVS data to highlight the BRICS region's potential as a potential investment destination for technopreneurs and providers of technology entrepreneurship venture capital. The total score for openness to entrepreneurship, as well as attitudes towards science and technology, was used to rank the five countries on their technological entrepreneurship readiness.

All the countries had significantly different mean scores for attitudes towards science and technology, with China ranked first, followed by Russia, India, South Africa and then Brazil. This result supports the BRICS body's 2020 estimates, which show China and Russia as the BRICS bloc's leading countries in terms of frontier technology readiness. While the BRICS data ranks Brazil just behind China and Russia on frontier technologies readiness, the WVS data suggests that it is the country with the worst attitude towards science and technology in the BRICS bloc. However, all the countries studied scored higher than the average, indicating that their populations had generally positive attitudes about science and technology. This illustrates that, despite some countries being more friendly than others, societal values in all BRICS countries are amenable to science and technology-related economic development. This analysis backs up prior observations that demonstrate a high degree of interest in science and technology issues among most of the BRICS countries (Tripathi & Brahma, 2018; Marques et al., 2019; Yu et al., 2009). Given that more than half of the Brazilian respondents did not complete their secondary education, the positive result for that country is somewhat reassuring for supporters of technology-based progress. If one assumes that a higher degree of education equates to greater exposure to scientific and technology concerns, more positive attitudes about science and technology would be expected in countries with better educated respondents and *vice versa*.

In terms of entrepreneurship openness, the pattern of mean scores showed that South Africa was ranked first, followed by China, Brazil, India and Russia. The mean scores for the variable differed significantly between countries. Surprisingly, just three nations (South Africa, China and Brazil) scored higher than the median in terms of their citizens' openness to enterprise issues. Thus, based on the values reflected in the WVS data, Russia and India can be characterised as the least supportive investment destinations for general entrepreneurship. This result was unexpected and perhaps contradicts the World Bank's 2018 Ease of Doing Business rating, which ranks Russia second only to China among the BRICS countries, in terms of having a business-friendly climate. In terms of ease of doing business, India ranks higher than South Africa and Brazil, according to the World Bank. It is possible that, while policymakers in Russia and India are devoted to establishing a favourable climate for investors, the local people's values are incompatible with an entrepreneurial way of life.

Over and above the rankings for openness to entrepreneurship, and attitude towards science and technology, all five countries indicated above-average readiness for technological entrepreneurship. China, however, displayed the most preparedness, followed by South Africa. The remaining countries examined fell into the same homogeneous subset, even though Russia was the most prepared in that group, followed by Brazil and then India. The study's results support prior research that accentuates China's leading position as a favourable destination for technological entrepreneurship. China's domination over all other countries was expected given that, according to the BRICS (2020), the country has invested far more in research and development than any other BRICS country. Furthermore, data in the literature suggests that China has a stronger technological entrepreneurship ecosystem than the other countries (He, 2019; Yu, 2009). South Africa's strong result was somewhat surprising, given that the country trails some BRICS countries on ease of doing business, frontier technological capabilities and competitiveness. One probable explanation could be that the government's entrepreneurial strategy resonates with the majority of the unemployed and/or self-employed population throughout the years, hence the positive result.

Conclusion and implications

The BRICS bloc is predicted to be a major economic force on the global scene by 2050. Arguably, an integral driver of this rapid economic expansion in the individual countries in the group is the nature and extent of entrepreneurial activity. Considering this, the economies with the most intense entrepreneurial activity are expected to emerge as key players in the economic development of this grouping. The outcome of the present study suggests that the BRICS countries have different degrees of technological entrepreneurship readiness. However, all the BRICS countries had a reasonable level of readiness for technological entrepreneurship. China stood out as having the most favourable social values for technology entrepreneurship, making it a potentially receptive investment destination for technopreneurs.

The study's observations guide policymakers in the various BRICS countries in the right direction, in terms of where they should focus their efforts to instill a culture of openness to technology entrepreneurship among their citizens. Additionally, potential investors and technopreneurs looking to invest in the BRICS region can utilise the results of this research to determine which investment destinations are most likely to succeed. Finally, the results add to the literature on technological entrepreneurship by giving empirical information on the status of readiness for technopreneurship in the BRICS countries from a values perspective.

Although this study produced some useful conclusions for many stakeholders, it does have a key limitation. The three primary factors, attitude towards science and technology, openness to entrepreneurship and technological entrepreneurship readiness, were assessed using proxy measures that were not intended particularly to assess the variables. To improve the credibility of future studies on the same topic and context, specific and validated measurement scales should be used.

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