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SOCIOECONOMIC INDICATORS DETERMINING INNOVATION: ASSOCIATION BASED ON DATA MINING

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Abstract – The sustained growth of an economy is linked to innovations in various sectors. An analysis based on economic indicators can guide the aspects of the economy to be prioritized for the creation of an environment conducive to innovation in a country. Thus, this study analyzed the most relevant socioeconomic aspects in constructing an innovative environment with the contribution of data mining through the J48C algorithm, demonstrating how data mining can contribute to the development of models for governmental decision-making and the construction of public policies. A total of 119 socioeconomic indicators were used, and 32 countries available in the innovation ranking of the Global Innovation Index (GII) 2020 report were selected. For data processing, the decision tree technique was adopted using the WEKA software and based on the C4.5 algorithm. The countries include the most and least innovative by region, which were processed via data mining through the supervised J48C algorithm. To highlight the socioeconomic indices most related to the more or less innovative outcome, a separation of the indicators by Pillars based on the Global Innovation Index (GII) 2020 report was conducted. The results highlight demographic indicators, labor

availability, production of goods of both high and medium technology, and governmental efficiency in association with more innovative economies. The relevance of women's participation in business and the relationship between female entrepreneurship and innovation are also highlighted. Most related research with pillar and indicator contributed to the findings and validated data mining as a method to investigate issues related to the development of economies through innovation.

Keywords: Innovation, Ranking, Economic Indicators, Data Mining, J48C.

INTRODUCTION

The contribution of innovation to the development of a country is well documented in various studies. It is undeniable that innovation assumes an important market value and that the most innovative countries are more economically developed, especially in an increasingly connected world with intensification of communication speed. The sustained growth of an economy is linked to innovations in various sectors. In this direction, an analysis based on economic indicators can guide the aspects of the economy to be prioritized for the creation of an environment conducive to innovation in a country (Souza, Hora, and Azevedo Filho, 2023).

In this context, Endovitsky, Treshchevsky, and Terzi (2020) highlight how the digital age and the use of technologies are differentials in the innovation process. Measuring economies is important to verify the gains and losses in the competitive process and to ponder the results and verify which ones contribute the most to the analysis of both perspectives and the management of the economic process in this scenario. Nelson (2006) considers it important to analyze the strengths and weaknesses of this economic system and has in mind that understanding the mechanisms of technological advancement requires more detail. Thus, he proposes a refinement of the initial understanding of the issues discussed by the Austrian economist, highlighting new interfaces of the current capitalist system.

Therefore, analyzing the success parameters in the innovation process of a

country through its economic indicators in the light of data science, aiding in the understanding of which aspects of the social sphere and the economy contribute to an innovative environment in a country throughout its history, is a research opportunity. Thus, the work proposes to analyze the most relevant socioeconomic aspects in the construction of a country's innovative environment with the contribution of data mining through the J48C algorithm. For this purpose, 119 socioeconomic indicators were used, and 32 countries available in the innovation ranking of the Global Innovation Index GII (Cornell University, INSEAD, WIPO, 2020) were selected. The work also intends to demonstrate how data mining can contribute to the development of models for governmental decision-making and the construction of public policies. It is worth noting that the analysis profile of this research does not consider political, cultural, and specific aspects of each economy, seeking an understanding of common variables to all economies that seek to follow a path of innovation.

The following sections of the work are organized into an existing literature review on the subject, followed by detailing the methodology used, where we will present the process of selecting countries and the economic indicators considered, as well as the J48C algorithm. Then, the findings will be presented and discussed, and the conclusions of the work will be presented.

LITERATURE REVIEW

Innovation is the engine of economies around the world. In a world where sustainability, globalization, improvement of communications, and technological and scientific advancement are undeniable and intrinsic factors to the entire model of progress and development, the challenge of transforming economic fragilities into strengths is the task of each country. Added to this is an increasingly competitive scenario that requires quick and effective decisions (Souza, Hora, and Azevedo Filho, 2023).

other hand, understanding the factors that permeate a country's success in the aspect of innovation in its production of goods and services is something that requires exhaustive studies to be able to delineate the best diagnosis on this path. When

analyzing the performance in research and development (R&D) of 25 European countries, De La Paz-Marín et al. (2012) used economic indicators related to patents, scientific productions, and investments with R&D to examine these countries through the use of algorithms. The result showed the formation of clusters of these places and their performances in innovation.

The use of big data has transformed the way of analyzing information from markets, companies, and businesses through technological tools that assist in the views of the economy from production processes to interference in society, contributing to the understanding of how the mechanisms of each organization behave. This use of technology translates into competitive advantages for the industry by providing results that effectively support decision-making (Demchenko, Gruengard, Klous, 2014).

Li (2016) states that big data is the new oil, a new asset that has a profound mark on science, technology, industry, and management procedures. Analyzing some provinces in China, the author emphasizes that using this resource associated with the innovation process is changing the way of thinking, generating economic growth, and promoting innovative development.

The processing of this data occurs through technologies and techniques involving steps such as selection, extraction, treatment, adequacy, storage, and dissemination of these elements (Victorino et al., 2017). Wu et al. (2008) described the algorithms most used in the big data environment, contributing to an understanding of the resources available to obtain a diagnosis of various databases in different economic segments.

Omelchenko, Kazban, and Drobotenko (2021) reinforce the importance of the increase in data science, assisting the understanding of the mechanisms of the innovation process and contributing to economic development by optimizing the efficacy of the analyses of works and their results. All of this reflects on the improvement of the quality of life of the general population.

Following this analysis proposal, several studies use data science to measure innovation in companies, economic sectors, and countries as a whole. In the formulation of public policies through the understanding of the economic aspects to be

increased or developed, the use of data volume can be a valuable resource for the knowledge of what contributes to the formation of an innovative process.

In order to analyze the innovation capacity of a province in China, the use of an algorithm helped Hongwei and Zhang (2017) to identify which aspects stand out in the formation of government policies in science and technology, proposing specific actions. Kuhlman and collaborators (2017) used data science to measure the level of innovation of 150 countries through indicators of global economic development. The authors highlighted the relationship between economic stability and statistics with good results in population health, which boosted the economy and the innovation process. Forner, Oscan, and Bacon (2019) analyzed 120 countries between 2014 and 2018 through the economic indicators of the Global Innovation Index (GII) report, forming clusters of countries through correlation. The results indicated that the use of machines assists in identifying aspects in the clusters that can serve as inputs for government decision-making.

METHODOLOGY

This study evaluated the data of 32 countries selected among the regional innovation leaders among those classified by the GII of 2020. As the data mining technique requires diversity for the association of the study indicators with the desired outcome "not innovative" or "innovative" (Cornell University, INSEAD, WIPO, 2020), countries in worse positions were also delimited, as there would not be a method capable of finding substantial differences if all the elements of the analysis had the same data standard with a homogeneous classification as "innovative."

In the organization by regions of the selected economies, the United Nations classification was used, namely: EUR refers to Europe; NAC to North America; LCN to Latin America and the Caribbean; CSA to Central and Southern Asia; SEAO to Southeast Asia, East Asia, and Oceania; NAWA to North Africa and West Asia; and SSF to Sub-Saharan Africa.

The socioeconomic indicators adopted are based on the GII 2020 and were

selected for highlighting issues that contribute to a country's innovation process. For data processing, the decision tree technique of Perez (2016) was adopted using the WEKA software (WEKA 2020) and based on the C4.5 algorithm (Quinlan, 1986).

Among the countries are the most and least innovative by region classified through 119 historical and socioeconomic indicators between 1960 and 2020, which were processed via data mining through the supervised J48C algorithm (Perez, 2016).

Data: Selected Countries and Socioeconomic Indicators

Using the ranking of 131 countries from the GII 2020 as a basis, the study selected 32 countries among the most innovative (Innovative) and the least innovative (Not Innovative) by region. For each region, the 2 most innovative and the 2 least innovative countries were listed. It should be noted that in the case of Latin America and the Caribbean (LCN), the research selected the four least innovative countries so that Brazil would be included in the selection; in the region of South and East Asia and Oceania (SEAO), the 5 most innovative countries were selected so that data from China and Japan would contribute to the analysis. In the North America (NAC) region, it is noteworthy that there are no less innovative countries, as the USA and Canada hold a prominent position in innovation among the world's economies.

Table 1 lists the countries in the study, as well as their positions and status in the global innovation ranking in 2020 (Cornell University, INSEAD, WIPO, 2020).

Table 1 - Countries, positions in the GII innovation ranking, regions, and status in 2020.

Countries	GII 2020 Position	Regions	Status 2020
India	48	CSA	Innovative
Iran, Islamic Republic	67	CSA	Innovative
Tajikistan	109	CSA	Not Innovative
Bangladesh	116	CSA	Not Innovative
Switzerland	1	EUR	Innovative
Sweden	2	EUR	Innovative
Bosnia and Herzegovina	74	EUR	Not Innovative
Albania	83	EUR	Not Innovative
Chile	54	LCN	Innovative
Mexico	55	LCN	Innovative
Costa Rica	56	LCN	Innovative
Brazil	62	LCN	Innovative
Colombia	68	LCN	Not Innovative
Bolivia	105	LCN	Not Innovative

Guatemala	106	LCN	Not Innovative
United States	3	NAC	Innovative
Canada	17	NAC	Innovative
Israel	13	NAWA	Innovative
Cyprus	29	NAWA	Innovative
Algeria	121	NAWA	Not Innovative
Yemen, Rep.	131	NAWA	Not Innovative
Singapore	8	SEAO	Innovative
Korea, Rep.	10	SEAO	Innovative
Hong Kong SAR, China	11	SEAO	Innovative
China	14	SEAO	Innovative
Japan	16	SEAO	Innovative
Lao PDR	113	SEAO	Not Innovative
Myanmar	129	SEAO	Not Innovative
Mauritius	52	SSF	Innovative
South Africa	60	SSF	Innovative
Niger	128	SSF	Not Innovative
Guinea	130	SSF	Not Innovative

Source: Prepared by the authors based on Cornell et al. (2020).

The socioeconomic indicators adopted in the study were selected based on the GII 2020 according to (Cornell University, INSEAD, WIPO, 2020). This choice is justified by the adherence of the indicators to the pillars used by the GII, being those that have a contribution to the innovation process of a country.

The 119 socioeconomic indicators were originated from the following databases: The World Bank (Malpass, 1944), UNESCO (Azoulay, 1970), World Intellectual Property – WIPO (Tang, 1967), International Organization for Standardization – ISO (Njoroge, 1946), SCImago (Anegón, 1996), UNIDO (Yong, 1966), ILOSTAT (Rider, 1996), United Nations (Guterres, 1945), Earthdata – NASA (Kusterer, 1994), EUROSTAT (Kotzeva, 1953), World Economic Forum (Schwab, 1971), and ITU News Magazine (Itu, 1865).

Table 2 displays the Pillars, the sources of the indicators, and the number of indicators used.

Table 2 - Pillars, source of indicators, and number of indicators

Pilar	Source of indicators	Number of indicators
Institutions	The World Bank	32
Human Capital and Research	The World Bank, UNESCO	27
Infrastructure	Earth Data Nasa, ISO, ITU News Magazine, The World Bank, United Nations	8

Market Sophistication	The World Bank, World Economic Forum	9
Business Sophistication	EUROSTAT, ILOSTAT, The World Bank, UNESCO, WIPO, World Economic Forum	20
Knowledge & Technology Outputs	ISO, SCImago, The World Bank UNIDO, WIPO	11
Creative Outputs	UNESCO, United Nations, WIPO	6
Health	The World Bank	6

Source: Prepared by the authors based on Anegón (1996), Azoulay (1970), Guterres (1945), Itu (1865), Kotzeva (1953), Kusterer (1994), Malpass (1944), Njoroge (1946), Rider (1996), Schwab (1971), Tang (1967), Yong (1966).

Processing of Variables

The research used the J48 Consolidated algorithm (Perez, 2016), with the outcomes “Not Innovative” (less innovative) and “Innovative” (more innovative), constructing decision trees. The technical details of the algorithm in question (Perez, 2016) underwent more in-depth analyses in the document “Induction of decision trees” (Quinlan, 1986). It should be noted that we used the WEKA® software (WAIKATO and Group, 1993) because it is open-source software, presents good performance, and provides reliable results.

The J48C algorithm is named C4.5 in the WEKA® software (WAIKATO and Group, 1993). The accuracy of J48C justifies its use; other works that used the methodology confirmed this attribute. In research on improving results in human resources, Zhang (2015) highlights that the C4.5 algorithm proved to be the algorithm with the highest precision in the results. Another study conducted by Wu and colleagues (2008) establishes the C4.5 algorithm among the most efficient in a list of 10 algorithms, which further reinforces the choice of method in this research.

Technical Procedures - Analysis by Pillar

The indicators were separated and classified according to the pillars, pointing out indicators associated with different areas with a focus on innovation, bringing specific mechanisms by segment analyzed. The indicators of each of the 8 pillars (“Education, Research & Human Capital”; “Infrastructure”; “Health”; “Market Sophistication”; “Institutions & Economy”; “Knowledge & Technology Outputs”;

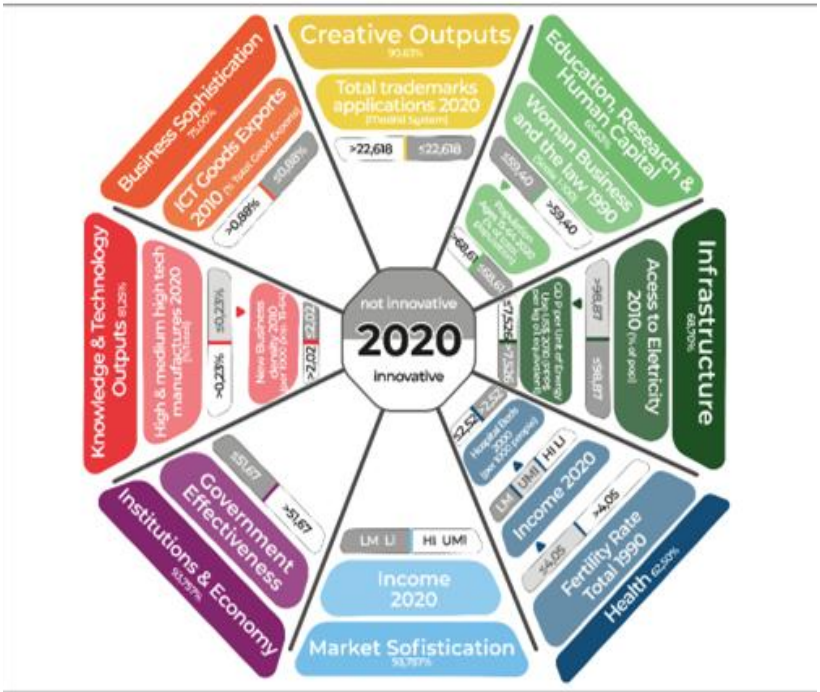
“Business Sophistication”; and “Creative Outputs”) were consolidated and executed in the WEKA® software (WEKA 2020). Their results demonstrated the level of correct classifications and highlighted mechanisms with their decision trees.

The level of correct classifications and confusion matrix were also made available in this work (supplementary material). The information was consolidated as per the next section.

RESULTS AND DISCUSSION

The resulting indicators were analyzed, and errors and inconsistencies were checked; then, the organization of information and the elaboration of tables and charts for better visualization of the findings were carried out. In addition, the article discusses data from algorithms with contributions from the scientific community according to relevant indicator and perspective.

The indicators classified according to the pillars of the GII report can be seen in Figure 1. Following are the evaluations of the indicators of each of the pillars.



Source: Prepared by the authors

HI = High-Income; UM I= Upper Middle-Income; LM = Low Middle-Income; LI = Low-income

Regions are based on the United Nations Classification: EUR = Europe; NAC = Northern America; LCN = Latin America and the Caribbean; CSA = Central and Southern Asia; SEAO = South East Asia and Oceania; NAWA = Northern Africa and Western Asia; SSF = Sub-Saharan Africa.

Innovative: More innovative; Not Innovative: Less innovative.

Institutions

The “Institutions” pillar assesses issues related to the political, regulatory, and business environments. Following the GII report, the indicators were associated with countries and their regions and the classification as more or less innovative (Cornell University, INSEAD, WIPO, 2020).

In this pillar, the results indicate "Government effectiveness 2010" as the attribute most strongly associated with the outcome of a country being more or less innovative in 2020, with economies with higher values being more innovative and those with lower values being less innovative during this period.

King and colleagues (1994) highlight the relevance of innovation worldwide, especially in the area of Information Technology (IT), already well established in more developed countries. The authors emphasize the need for the formulation and implementation of more specific governmental policies aimed at this market sector, being essential to understand the role of governmental institutions in its strengthening. The authors also expose three points to be considered in this understanding: the inadequacy of the established intellectual perspectives on innovation by the neoclassical and organizational theories that are not enough to explain innovation in terms of IT; secondly, it is highlighted how the interference of the regulatory power of institutions can contribute to the relationship between supply and demand in this segment; and as a third point, it is emphasized the need to understand the multidisciplinary function of institutions in providing motivation and contributing to the innovation process through their policies.

When quantitatively analyzing Chinese policies aimed at innovation between 1980 and 2008, Liu and colleagues (2011) highlight a different and more promising innovation trajectory. The effectiveness of the trajectory is due to a change in the strategy centered on industrial and scientific policy with economic and technological initiatives that are increasingly supported by innovation in Science and Technology (S&T). Such initiatives have shown to be better coordinated and oriented towards innovation with critical financial, taxation, and fiscal measures, with intergovernmental coordination instead of formulations by a single governmental agency.

In 2006, Zhu and colleagues conducted a survey with data from 1,857 companies from 10 countries to investigate the environment by comparing data from developed and developing countries. The study concluded that a well-structured regulatory environment performs better in more developed regions than in developing ones, asserting that the business context and integration of technologies, when associated with effective policies, result in effects that can vary at different stages and places.

The accuracy of the results in this pillar is verified through the percentage of 93.75%, which demonstrates the precision of the information. These data were made available at the end of this work in the form of supplementary material.

Human Capital & Research

The "Human Capital & Research" pillar focuses on issues related to education, higher education, and research and development, with the premise that higher education contributes to innovation (Cornell University, INSEAD, WIPO, 2020).

Analyzing the results of this Pillar, the indicator "Women Business and the Law" from 1990 stands out as the one with the highest association, with higher values of the indicator in more innovative countries in 2020 and vice versa. Thus, we can assume the relevance of this indicator, which deals with opportunities for women regulated by laws.

Although developed and developing nations already understand the contribution of entrepreneurial activities by women to socioeconomic growth and sustainable

development, Kamberidou (2020) highlights the barriers faced by women in their entrepreneurial initiatives. Through a review of recent literature with studies conducted between 2011 and 2019, the researcher evidences the fact that women face barriers such as multitasking, lack of financial resources, poor access to business networks, technology, and digital markets. Given this, the need for implementing equal opportunity policies and well-defined property rights, especially for women from developing countries, is emphasized. These analyses confirm the results of this research.

When analyzing 261 small and medium-sized enterprises led by women in Pakistan, Zeb and Ihsan (2020) found results indicating a strong relationship between female entrepreneurship and innovation. Skills such as taking risks and responsibilities were identified, generating effects in terms of innovation and business performance. The authors conclude that it is necessary for the government to develop public policies aimed at women as a recognition of this potential in terms of economic development in Pakistan.

Although well documented in various studies, there is not always a consensus that the growth of female entrepreneurship and the issue of gender are capable of explaining the innovative behavior in companies led by women, as pointed out by the study conducted by Fulculesco (2016). When evaluating qualitative data of economic indicators in a sample of six countries, the panorama found was highly heterogeneous, showing that the indicators used (percentage of female entrepreneurs, support for high growth of female entrepreneurship, and gender equality) are not good predictors of the level of innovation in businesses led by women. This conclusion contrasts with the results found in this work.

Following the analysis of this Pillar, for those countries with lower values in the "Women Business and the Law" indicator from 1990, the results establish an association with "Population Ages 15-64" referring to 2020. This attribute deals with the availability of the economically active population concerning the total population. The higher the values of this indicator, the more innovative the economies will be in that year, as well as the opposite.

Bloom and Williamson (1998) associated the economic growth of East Asia during the 20th century, between 1965 and 1990, with the demographic transition that resulted in a growth of the population of working age. This made the productive capacity of the region's economies stronger. However, the authors highlight that the transitional effect of population growth on economic growth is only efficient when there is growth at different rates of the economically active population from the dependent population.

Van Der Gaag and De Beer (2015) analyzed the proportion of the working-age population and economic growth in the countries of the European Union. The authors emphasized that employment targets might not be met due to the decline in the working-age population in Europe, highlighting a variation between the population of urban and rural regions. They also note that in sectors with less dependence on labor, the impacts of this decline are not as pronounced as in sectors that depend on human interaction.

Regarding the accuracy of the results in this pillar, a percentage of 65.63% is observed, which demonstrates the precision of the information. These data are made available at the end of this work (supplementary material).

Infrastructure

The "Infrastructure" pillar is based on three dimensions: information and communication technologies (ICTs), general infrastructure, and sustainability, considering countries that structure more efficient environments with lower transaction costs, based on sustainable growth, as more innovative (Cornell University, INSEAD, WIPO, 2020).

In this pillar, the attribute "Access to Electricity (% of population)" from 2010 stands out as the most associated with innovation, where economies whose population has more access to electricity are the most innovative in 2020. Conversely, those with lower assessments in terms of access to this factor are associated with the attribute "GDP per unit of energy use (constant 2017 PPP $ per kg of oil equivalent)".

The indicator "GDP per unit of energy use (constant 2017 PPP $ per kg of oil equivalent)" provides data related to GDP per unit of energy use. It reflects the relationship between the two issues, indicating energy efficiency, where the higher the values of this index, the greater the association with a high price or cost of converting energy into GDP, and vice versa. Economies whose values of this indicator are higher in 2010 would be less innovative in 2020, and vice versa.

The energy issue is a recurrent theme and demands urgent solutions. Kaygusuz (2012) pointed out that 1.4 billion people in the world do not have access to electricity, among which 85% are in rural areas. The author emphasizes that despite the trend of a reduction in these numbers by 2030, the energy issue still constitutes a challenge.

The energy situation requires multidisciplinary actions since, in addition to the issue of economic dependence on oil, pollution of the environment, and the high cost of energy generation, the supply of this resource lacks innovative solutions and accessible costs. In this sense, the adoption of efficient public policies worldwide is urgent.

Aker and Mbiti (2010) highlight the deficiency in electricity in Africa by associating this factor with the use of mobile phones in the region. In 1999, only 10% of the population had access to mobile phones; this number rose to 60% in 2008. Although the association between the use of mobile phones and tangible economic benefits, such as improvement in agricultural efficiency and the labor market, for example, the authors highlight that the deficiency in electricity in Africa threatens the increase in this use. Thus, the authors suggest the need for mobile phone companies to structure their own electricity generation.

Energy production is directly related to several issues, namely: environmental quality, sustainability, economic well-being, and national and international security. Two risks can be associated with this indicator: economic dependence on oil and issues of balance of payments and foreign policy connected to importation. The shocks in oil prices have a direct effect worldwide due to the strategic importance of this energy. In this sense, the environmental aspect related to sustainability, among other factors, contributes to the development of biofuels as an innovative path to be developed by economies (Holdren, 2006).

In this context, Wonglimpiyarat (2010) mentions Schumpeter's "long wave theories," which are associated with the cycles of "Kondratieff or long waves of economic development." The author emphasizes that oil is the fourth wave of this theory but comments on the importance of future-oriented work and cites actions of some countries. Germany, for example, in addition to exempting taxes, provided governmental subsidies for the production of biofuels. Japan, the third largest in terms of global oil consumption, behind the United States and China, has invested in the development of bioethanol.

Wonglimpiyarat (2010) also informs that the United States, responsible for 28% of global consumption, has focused its investments on hybrid vehicles, clean diesel, and biodiesel. China, in turn, limited the production of edible grains to increase the production of biofuels. The author highlights the speed of these innovations in proportion to energy demands.

The accuracy of the results in this Pillar is highlighted by the percentage of 68.75%, evidencing the precision of the information. These data are made available in the supplementary material of this work.

Market Sophistication

The "Market Sophistication" pillar of the GII report addresses issues related to credit availability, investments, trade, competitiveness, and market scale, with associations with countries and the more or less innovative outcome (Cornell University, INSEAD, WIPO, 2020).

In this pillar, the results indicate "Income" as the attribute most strongly associated with the outcome of a country being more or less innovative in 2020. It is also possible to understand that economies with High and Upper Middle Income are the most innovative during this period, and those economies with Lower Middle and Low Income are the least innovative, considering the context of Market Sophistication.

Examining the financial development of 94 countries between 1968 and 2015, Chu (2019) showed that both the banking sector and the stock market have positive effects on market sophistication, relating to the increase in investments in innovation

and economic development. It is noted that countries with High Income have a more developed banking sector than those with Upper Middle Income.

Jintana et al. (2020) verified the innovation process of the member countries of the economic bloc Association of Southeast Asian Nations (ASEAN), which involves Thailand, Philippines, Malaysia, Singapore, Indonesia, Brunei, Vietnam, Myanmar, Laos, and Cambodia. The authors used the 2019 Global Competitiveness Report and the pillars of the report, which include institutions, human capital and research, infrastructure, market sophistication, and business sophistication.

The authors highlighted the innovative process as a key point for economic development, emphasizing Singapore as the country with the highest competitiveness and the best innovation environment in the world. Meanwhile, Brunei is a positive highlight in terms of institutions and infrastructure, and Cambodia has a good market sophistication pillar as there is ease in access to credit as a percentage of GDP, although it has tariffs and intensity in competition which are considered constraints (JINTANA et al., 2020).

Through autoregression, Pradhan et al. (2017) verified the relationships between innovation and both financial and economic growth of 18 Eurozone countries between 1961 and 2013. The results showed that the development of the sector and the increase in innovation are factors that contribute to the economic growth of the countries in the region in the long term. The authors emphasize that investments in research and development (R&D) are essential to boost the innovation process of these countries.

The accuracy of the results of this pillar is verified through the percentage equivalent to 71.88%, which reveals the precision of the information. These data were made available at the end of this work (supplementary material).

Business Sophistication

The “Business Sophistication” pillar seeks to understand, through economic indicators, the level of businesses prone to innovative activity and research activities. In addition to "Human Capital & Research," this pillar evaluates data on highly skilled

labor, women pursuing postgraduate studies, and innovation activities between universities, companies, and the public sector (Cornell University, INSEAD, WIPO, 2020).

The results associated with this pillar pointed out the attribute Information and Communication Technologies “ICT Goods Exports (% Total Goods Exports) 2010” as the most strongly associated with the outcome of economies being more or less innovative in 2020. This indicator tracks the share of exports related to "Information and Communication Technologies" in total exported products. Thus, it can be assumed that economies that performed better in this indicator in 2010 would be the most innovative in 2020. In this line, those that had a negative performance in 2010 would be the least innovative in 2020.

Heeks (2010) analyzes the contribution of the diffusion and use of technologies as value chains for economic development. The author states that the contribution in diffusion and use of technology by mobile phones is easily detectable, but the focus has been shifted to evaluating the impact of this availability of ICTs on development.

In this way, Heeks (2010) suggests the participation of ICT-specialized researchers among policymakers for the sector, affirming that there is a separation between progressive ICTs that provide but do not change development structures and transformational ones that incorporate entirely new business models.

Aligned with this direction, Avgerou (2010) suggests improvements in the understanding of ICT concepts by identifying innovation processes in these concerning developing countries. He also emphasizes that systematizing them for the socioeconomic context to assist in innovation actions contributes to improving life in the highlighted scenario.

Freeman (2002) brings an argument aligned with innovation, stating that a key factor for global competition is the ability of countries to use information, communication, and technology for service provision. The author makes it clear that the industry of ICT goods does not show a drop in productivity, being strategic for large companies in this sector to offer certain services that will predominate in the portfolio of multinationals. To exemplify, he highlights services aimed at the financial, marketing, software, design, and R&D areas.

The accuracy of the results in this pillar is verified through the percentage of 75%, which reveals the precision of the information. These data were made available at the end of this work in the form of supplementary material.

Knowledge & Technology Outputs

The “Knowledge & Technology Outputs” pillar evaluates the creation of knowledge, its impact, and dissemination, analyzing products originated from innovation, such as citations of scientific research, patent registrations, new company openings, software spending, and ISO certificate issuances (Cornell University, INSEAD, WIPO, 2020).

The results highlight two indicators that have a strong relationship with the outcome of the economy being more and less innovative in 2020. The first is “High & medium high-tech manufactures (% Total) 2020,” by which countries with higher values of production of high and medium technology goods are the most innovative in 2020, just as those with lower indices are associated with the second indicator “New businesses per 1000 pop. 15-64_2010”.

When analyzing the economies of the OECD (Organization for Economic Cooperation and Development) considering high-technology productions between 1990 and 2003, Schneider, Schulze, and Paunescu (2010) assert that there is a positive relationship between university graduates and the stock market, which contributes to good performances in the exports of high-technology products in these economies.

The same authors consider that mergers and partnerships of large companies in this type of market are aspects that intensify the production of high technology and believe that when analyzing the issue of job opportunities, it can be understood how having job stability does not promote losses or gains in terms of productivity in the performance of high-technology exports (Schneider, Schulze, and Paunescu, 2010).

When studying the innovative performance of technology from 2009 to 2018 in terms of efficiency in Ukraine, Vasyltsiv et al. (2020) suggest some aspects in terms of public policies: simplification of the import of technology equipment; protection under

property rights; greater availability of financial funds and credit; improvement of the environment contributing to greater competitiveness through public guarantees of investments; simplification of licensing and taxation procedures; prioritization of high-technology intensive products in bidding systems; and accessibility to international quality standards.

The second attribute associated with countries with lower values in “High & medium high tech manufactures 2020 (% Total)” is “New business per 1000 pop. 15-64_2010”. This indicator measures data related to the creation of new companies involving the population between 15 and 64 years for every 1000 people. Economies that present the highest values in this attribute are the most innovative in 2020, and the inverse relationship is also observed.

Despite the well-established relevance of new business development for economic transition and growth, De Clercq et al. (2010) highlight the fact that few publications examine the association between institutional factors and new business development in emerging economies. To address this gap, they assessed the relationship between institutions and new businesses in emerging economies using data from two transnational projects, the "Global Entrepreneurship Monitor and World Values Survey". The study identifies a positive relationship between coordinated activities and new companies, notably for higher regulatory and normative institutional charges, which suggests a more strengthened market configuration in this setup.

When analyzing developing countries, a structural change and economic growth related to entrepreneurship are identified. It is also noted that the creation of new companies and new businesses is an alternative for reducing wealth inequality as new ideas emerge, heating up markets and promoting economic development through innovation and new job opportunities.

However, easy access to credit and financing is necessary for it to be possible to unite productive technologies and entrepreneurial talent. Otherwise, if this bottleneck related to access to financing and credit persists, income inequalities, poverty, and information asymmetries will not be reduced (Naudé, 2010).

The accuracy of the results of this pillar is verified through the percentage of 81.25%, which reveals the precision of the information. The data were made available

at the end of this work in the form of supplementary material.

Creative Outputs

According to the GII report (Cornell University, INSEAD, WIPO, 2020), the "Creative Outputs" pillar is still underestimated in terms of measurement and policies aimed at innovation because it includes intangible assets such as trademark applications by residents, entertainment and media production, information services, advertising, cultural productions, and recreational services.

In this research, the attribute “Total trademark applications (Madrid system) 2020” proved to be strongly related to the outcome of the economy being more or less innovative in 2020. The indicator deals with trademark applications by residents and indicates that economies with higher values associated would be the most innovative in 2020, and those with lower values would be the least innovative in the same period.

The registration of trademarks adds a series of factors to innovation processes, being considered an indicator capable of contributing to the understanding of this market. Analyzing Portugal, Mendonça et al. (2004) indicate that the study of brands can be a predictor of relevant aspects of innovation and industrial transformation. Brands are competition tools, and the country witnessed an increase in registrations from the 1990s. Countries like Ireland and Austria have strong marketing. Meanwhile, Portugal has improvements to be made in this sense, but it acts in a structural way.

Given the importance of the topic, Buttice et al. (2020) conducted a study to assess the effects of brand counterfeiting on the economic performance and innovative activities of companies, evaluating data from customs seizures worldwide between 2011 and 2013 with financial accounting information, patents, and registered trademarks for a sample of digital technology companies, especially involving products such as high-tech hardware. The work highlights a worsening of the profitability of technology companies due to counterfeiting. Although the companies do not have an impact on sales, operating profits are affected by investments in product differentiation, anti-counterfeiting practices, and monitoring the circulation of counterfeits.

Intellectual property in the USA was strengthened with judiciary legislation, as

this regulation motivated companies to intensify their research in R&D and facilitated the processes of acquisition and sale of technology transfer. Licensing policies further increased the value of patents, for example, in business strategies (Mowery & Rosenberg, 2005).

The accuracy of the results of this pillar is verified through the percentage of 91%, which reveals the precision of the information. The data were made available at the end of this work in the form of supplementary material.

Health

The last evaluated pillar, not included in the GII report, considers factors that permeate people's health as a differential for the formation of an innovative ecosystem. It assumed the attribute "Fertility rate total_1980" with the highest association with the more or less innovative outcome in 2020. The total fertility rate represents the average reproductive condition of women, evaluated by the average number of live births per woman at the end of her reproductive period. Considered the main indicator of demographic dynamics, it indicates that economies with high total fertility rates are less innovative.

Otherwise, when economies have lower fertility rates, they are associated with a second indicator: the Income Level "Income" in which countries with Lower Middle Income are the least innovative in 2020. Those with High Income are associated with the most innovative in 2020.

Following this, countries with Upper Middle Income are associated with the third attribute "Hospital Beds (per 1000 people)" from 2000, considering that regions that had more beds in that period are the least innovative, and vice versa. It is worth noting that this indicator includes hospitalization beds available in public, private, general, and specialized hospitals, and rehabilitation centers. Most involve beds for acute and chronic care.

Okun (1997) analyzes innovation and changes in fertility rates due to the immigration of Jews to Israel from Africa and the Middle East. The author states that innovation reflects changes in socioeconomic conditions that make fertility control

advantageous, as the cost-benefit ratio of having children is reevaluated.

Futagami and Konishi (2019) consider factors that contribute to the results of this work, as they associate fertility rates with income and technological progress. The authors develop a model divided into three stages: in the first, they conclude that the fertility rate increases with the economic development of the country even when per capita wage income is low. In the second, when it is medium, the fertility associated with technological progress decreases. In the third, they understand that when per capita income is high and technological progress increases, the fertility rate follows this flow.

The "Income 2020" is the second attribute resulting in the "Health" Pillar and indicates that the most innovative economies in 2020 are those with high income; when they have lower income, they are the least innovative in that period. It is worth noting that the "Income" attribute refers to the mentioned year and was taken from the GII report.

Contributing to the results of this research, the analysis of high-income OECD countries associates the size of this and the innovation rate considering patenting Granger to the increase in R&D activities, which also increases income levels, which generate the same phenomenon in R&D investments and reflect in more innovation (Guloglu & Tekin, 2012).

Otherwise, Taskin and Zaim (1997) investigated the relationships between per capita income, potential efficiency rate, innovation rate, and productivity growth of 23 countries between 1975 and 1990. The authors conclude, through the Malmquist productivity index obtained by linear programming, that poor countries grow faster than rich ones. Thus, there is a possibility that those who are poor reduce the distance in relation to those with high income in terms of productivity and innovation. It is noted that although the income studied does not refer to 2020 but to the period between 1975 and 1990, the analysis of the authors does not reinforce the results of this research.

The third stage comprises countries with Upper Middle Income, which are associated with the attribute "Hospital Beds (per 1000 people) 2000," which shows that regions that had more beds in 2000 are the least innovative in 2020, highlighting that those with fewer beds in 2000 are the most innovative in the already mentioned year.

It is worth highlighting that, according to the definition of The World Bank Malpass (1944), most of the beds linked to the indicator are also related to treatments for acute or chronic conditions.

Anderson and Hussey (2001), when analyzing data from 29 OECD and WHO countries on health systems, found that there are diseases whose immunization rates reach almost 100%, such as measles, diphtheria, whooping cough, and tetanus, and highlight the fact that since 1980, immunization has increased in countries such as the United States, Australia, and the United Kingdom. Some of the strategies to achieve this increase can be cited: in Australia, the government offers money to parents and doctors to immunize children; in the United Kingdom, doctors are financially rewarded for reaching planned immunization levels; in Georgia, this goal is achieved through returns on immunization services.

Furthermore, the aforementioned study highlights that although per capita health expenditures have remained considerably high, there has been a reduction in hospital beds in the USA in parallel to this aspect.

Another study conducted by Proksch et al. (2019), using a multi-indicator approach with data from OECD countries, investigated how these could be evaluated in the production of health innovation. The authors compared the health innovation results of 30 European countries, categorizing them into four distinct groups through cluster analysis. Despite being a challenge to assess a country's innovation capacity, the authors consider aspects such as population aging as a motivating factor to think about innovative solutions for the health area.

It is observed that the accuracy of the results in this pillar presents a percentage of 63%, something capable of highlighting the precision of the information. These data were also made available at the end of this work.

CONCLUSION

This research aimed to analyze which variables contribute to the success in an innovation process in 32 more and less innovative countries, which were selected through the innovation ranking of the Global Innovation Index (GII) report of 2020. For

this purpose, historical socioeconomic indicators from 1960, 1970, 1980, 1990, 2000, 2010, and 2020 were used via the J48C algorithm, which was considered the guiding tool of this analysis.

It is worth noting that this research did not intend to address the specificities of each country, nor did it consider political and cultural aspects. The central idea was to discuss the common factors to the selected regions regarding innovation.

Thus, a separation of the indicators by Pillars based on the Global Innovation Index (GII) 2020 report was conducted: “Education, Research & Human Capital”; “Infrastructure”; “Health”; “Market Sophistication”; “Institutions & Economy”; “Knowledge & Technology Outputs”; “Business Sophistication”; and “Creative Outputs”. This perspective involved results that highlighted the socioeconomic indices most related to the more or less innovative outcome for each of the eight highlighted pillars.

In this view by Pillars, it is noted that demographic issues, labor availability, production of goods of both high and medium technology, and governmental efficiency were highlights. It is possible to add the relevance of women's participation in business and the findings of research capable of contributing to this result by affirming that in developed countries, female entrepreneurship and innovation are correlated.

Moreover, the highlight of the indicators associated with trademark registration and the opening of new companies reveals how innovative entrepreneurship is a segment to be enhanced in terms of public policies.

Regarding energy costs and access to electricity, the energy issue was considered relevant in the results found, reinforcing that innovation requires infrastructure and cost reduction. It is observed that the dependence on oil and the search for alternatives in access to electricity permeate the innovative process.

The quality in the regulation of markets aiming at the development of the private sector and governmental efficiency in the elaboration and implementation of public policies are notorious aspects in the innovation process. These movements reveal that the State's performance is analogous to a company; innovation requires multidisciplinary action, with industrial policies, investments in R&D, infrastructure in

information and communication technology, attraction of investors, among others related to management bottlenecks.

In the health area, the indicator “Hospital Beds” when associated with the Innovative and Not Innovative outcome reveals how the increase of innovative solutions to improve health conditions is a differential factor among countries. Therefore, developing innovative responses related to the numerous challenges that health demands is a serious point of attention.

Most of the related research with pillar and indicator contributes to the results found and validates data mining as a method to investigate issues related to the development of economies through innovation.

The State can prioritize the needs for elaboration and execution of public policies aimed at innovation through some algorithm. As verified, many economic sectors use this resource to complement conventional evaluations, generating solutions for the improvement of people's living conditions worldwide.

Research Limitations

It is important to highlight the limitations of this research, which does not consider political, historical, and cultural aspects. In addition, specific economic issues of each country were not used for discussions. Another limitation to be highlighted is the causality relationship: this work does not determine a relationship between the socioeconomic indicator and the innovative or not innovative outcome, so it demonstrates how there is something in common between the economies, the development of each one, the socioeconomic indicators, and the innovation. It is believed that the proposed discussion can motivate the understanding of these mechanisms, which relate the more or less innovative countries in 2020 selected and the socioeconomic indicators assigned throughout this research. In addition, their visions by decades and by pillars via the J48C algorithm were also considered.

REFERENCES

ADEDOYIN, F. F. et al. Modelling coal rent, economic growth and CO2 emissions: Does regulatory quality matter in BRICS economies?. Science of The Total Environment, v. 710, p. 1-15, mar. 2020. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0048969719362801?via%3Dihub. Accessed on: 15 dez. 2020.

AKER, J. C.; MBITI, I. M. Mobile Phones and Economic Development in Africa. Journal of Economic Perspectives, v. 24, n. 3, p. 207-232, ago. 2010. Available at: https://www.aeaweb.org/articles?id=10.1257/jep.24.3.207. Accessed on: 14 dez. 2020.

ANDERSON, G.; HUSSEY, P. S. Comparing Health System Performance In OECD Countries. Health Affairs, v. 20, n. 3, p. 219-232, maio 2001. Available at: https://www.healthaffairs.org/doi/abs/10.1377/hlthaff.20.3.219. Accessed on: 14 dez. 2020

ANEGÓN, F. de M. SJR - Scimago Journal & Country Rank, 1996. Ranking dos Países. Available at: https://www.scimagojr.com/countryrank.php. Accessed on: 3 dez. 2020.

AVGEROU, C. Discourses on ICT and development. Information Technologies and International Development, v. 6, n. 3, p. 24, jan. 2010. Available at: https://www.researchgate.net/publication/254436277_Discourses_on_ICT_and_development. Accessed on: 15 dez. 2020.

AZOULAY, A. UNESCO - The UNESCO Institute for Statistics (UIS), 1970. Página Inicial. Available at: http://uis.unesco.org/. Accessed on: 27 out. 2020.

BLOOM, D. E.; WILLIAMSON, J. G. Demographic Transitions and Economic Miracles in Emerging Asia. The World Bank Economic Review, v. 12, n. 3, p. 419-455, 1998. Available at: https://www.jstor.org/stable/3990182?seq=1. Accessed on: 1 nov. 2020.

BUTTICE, V. et al. Counterfeiting in digital technologies: An empirical analysis of the economic performance and innovative activities of affected companies. Research Policy, v. 49, n. 5, p. 1-15, jun. 2020. Available at: https://www.sciencedirect.com/science/article/pii/S0048733320300391. Accessed on: 9 dez. 2020.

CASTIGLIONI, M.; ZUANNA, G. D. Innovation and tradition: Reproductive and marital behaviour in Italy in the 1970s and 1980s. European Journal of Population, v. 10, n. 2, p. 107-141, jun. 1994. Available at: https://www.jstor.org/stable/20164686?seq=1. Accessed on: 4 dez. 2020.

CHEAH, S. L.-Y.; HO, Y.-P. Effective industrial policy implementation for open innovation: The role of government resources and capabilities. Technological Forecasting and Social Change, v. 151, p. 1-9, fev. 2020. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0040162518315208. Accessed on: 22 nov. 2020.

CHU, L. K. The effects of financial development on economic sophistication: evidence from panel data. Applied Economics Letters, v. 27, n. 15, p. 1260-1263, out. 2019. Available at: https://www.tandfonline.com/doi/abs/10.1080/13504851.2019.1676866. Acesso em: 21 nov. 2020.

Cornell University, INSEAD, and WIPO - World Intellectual Property Organization, 2020. Global Innovation Index 2020. Available at: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2020.pdf Accessed on: 4 nov. 2020.

DE CLERCQ, D.; DANIS, W. M.; DAKHLI, M. The moderating effect of institutional context on the relationship between associational activity and new business activity in emerging economies.

International Business Review, v. 19, n. 1, p. 85-101, fev. 2010. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0969593109001188. Accessed on: 26 nov. 2020.

DE FRANCESCO, F.; RADAELLI, C. M.; TROEGER, V. E. Implementing regulatory innovations in Europe: the case of impact assessment. Journal of European Public Policy, v. 19, n. 4, p. 491-511, maio 2012. Available at: https://www.tandfonline.com/doi/full/10.1080/13501763.2011.607342. Accessed on: 1 dez. 2020.

EL ARIFEEN, S. *et al*. Community-based approaches and partnerships: innovations in healthservice delivery in Bangladesh. The Lancet, v. 382, n. 9909, p. 2012-2026, dez. 2013. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0140673613621492?dgcid=api_sd_sea%20rch-api-endpoint. Accessed on: 1 nov. 2020.

FILCULESCU, A. The heterogeneous landscape of innovation in female led-businesses - cross-country comparisons. Management & Marketing. Challenges for the Knowledge Society, v. 11, n. 4, p. 610-623, dez. 2016. Available at: https://www.sciendo.com/article/10.1515/mmcks-2016-0019. Accessed on: 9 nov. 2020.

FORNER, D.; OZCAN, S.; BACON, D. Machine Learning Approach for National Innovation Performance Data Analysis. In: 8TH INTERNATIONAL CONFERENCE ON DATA SCIENCE, TECHNOLOGY AND APPLICATIONS - DATA. Prague, 2019. Anais [...]. England: University of Portsmouth, 2019. FREEMAN, C. Continental, national and sub-national innovation systems—complementarity and economic growth. Research Policy, v. 31, n. 2, p. 191-211, 2002. Available at: http://sro.sussex.ac.uk/id/eprint/19008/. Accessed on: 25 nov. 2020.

FUTAGAMI, K.; KONISHI, K. Rising longevity, fertility dynamics, and R&D-based growth. Journal of Population Economics, v. 32, n. 2, p. 591-620, abr. 2019. Available at: https://link.springer.com/article/10.1007/s00148-018-0691-2. Accessed on: 22 nov. 2020.

GOMES, A. M. G. Aplicação de Machine Learning no Combate ao Branqueamento de Capitais e ao Financiamento do Terrorismo. p. 51, 2019.

GUAN, J.; CHEN, K. Measuring the innovation production process: A cross-region empirical study of China's high-tech innovations. Technovation, v. 30, n. 5-6, p. 348-358, maio 2010. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0166497210000301. Accessed on: 5 nov. 2020.

GULOGLU, B.; TEKIN, R. B. A Panel Causality Analysis of the Relationship among Research and Development, Innovation, and Economic Growth in High-Income OECD Countries. Eurasian Economic Review, v. 2, p. 32-47, jun. 2012. Available at: https://link.springer.com/article/10.14208/BF03353831. Accessed on: 26 out. 2020.

GUTERRES, A. The United Nations (UN), 1945. Página Inicial. Available at: https://www.un.org/en/. Accessed on: 12 nov. 2020.

HEEKS, R. Do information and communication technologies (ICTs) contribute to development? Journal of International Development, v. 22, n. 5, p. 625-640, jun. 2010. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1002/jid.1716. Accessed on: 18 nov. 2020.

HERZER, D. How does mortality affect innovative activity in the long run? World Development, v. 125, p. 1-15, jan. 2020. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0305750X19303365. Accessed on: 19 nov. 2020.

HOLDREN, J. P. The Energy Innovation Imperative: Addressing Oil Dependence, Climate Change, and Other 21 st Century Energy Challenges. Innovations: Technology, Governance, Globalization, v. 1,

n. 2, p. 3-23, fev. 2006. Available at: https://www.researchgate.net/publication/24089983_The_Energy_Innovation_Imperative_Addressing_Oil_Dependence_Climate_Change_and_Other_21_st_Century_Energy_Challenges. Accessed on: 1 nov. 2020.

ITU. ITU - The International Telecommunication Union, 1865. Home page. Available at: https://www.itu.int/en/itunews/Pages/default.aspx. Accessed on: 24 nov. 2020.

JINTANA, J. et al. Innovation Ecosystem of ASEAN Countries. Revista Amazonia Investiga, v. 9, n. 28, p. 356-364, abr. 2020. Available at: https://www.researchgate.net/publication/340851706_Innovation_Ecosystem_of_ASEAN_Countries. Accessed on: 1 dez. 2020.

JINTANA, J. et al. Innovation Ecosystem of ASEAN Countries. Revista Amazonia Investiga, v. 9, n. 28, p. 356-364, abr. 2020. Available at: https://www.researchgate.net/publication/340851706_Innovation_Ecosystem_of_ASEAN_Countries. Accessed on: 1 dez. 2020.

KAMBERIDOU, I. “Distinguished” women entrepreneurs in the digital economy and the multitasking whirlpool. Journal of Innovation and Entrepreneurship, v. 9, n. 3, p. 1-26, dez. 2020. Available at: https://innovation-entrepreneurship.springeropen.com/articles/10.1186/s13731-020-0114-y. Accessed on: 5 dez. 2020.

KAYGUSUZ, K. Energy for sustainable development: A case of developing countries. Renewable and Sustainable Energy Reviews, v. 16, n. 2, p. 1116-1126, fev. 2012. Available at: https://www.sciencedirect.com/science/article/abs/pii/S1364032111005491. Accessed on: 27 out. 2020.

KIM, L. Da imitação à inovação: a dinâmica do aprendizado tecnológico da Coréia. Rev. Econ. Polit., São Paulo, v. 26, n. 4, p. 632-633, dez. 2006. Available at: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0101-31572006000400012&lng=en&nrm=iso. Accessed on: 22 out. 2020.

KING, J. L. et al. Institutional Factors in Information Technology Innovation. Information Systems Research, v. 5, n. 2, p. 139-169, jun. 1994. Available at: https://www.jstor.org/stable/23010971?seq=1. Accessed on: 22 out. 2020.

KOTZEVA, M. EUROSTAT - European Statistical, 1953. Home page. Available at: https://ec.europa.eu/eurostat. Accessed on: 30 out. 2020.

KOVANOVA, E.; BADMAEVA, N.; ALEKSEEV, S. Demographic factor of intensification of innovation activity of Russian regions. E3S Web of Conferences, v. 210, p. 1-7, 2020. Available at: https://www.e3sconferences.org/articles/e3sconf/abs/2020/70/e3sconf_itse2020_19001/e3sconf_itse2020_190 01.html. Accessed on: 3 nov. 2020.

KUHLMAN, C. et al. How to foster innovation: A data-driven approach to measuring economic competitiveness. IBM Journal of Research and Development, v. 61, n. 6, p. 1-12, dez. 2017. Available at: http://ieeexplore.ieee.org/document/8167366. Accessed on: 15 dez. 2020.

KUSTERER, J. M. NASA’s Earth Science Data Systems (ESDS), 1994. Home page. Available at: https://earthdata.nasa.gov/. Accessed on: 19 nov. 2020.

LEE, C.-C.; OLASEHINDE-WILLIAMS, G.; OLANIPEKUN, I. Financial systems, regulatory quality, and economic growth. The Journal of International Trade & Economic Development, v. 30, n. 2, p. 246-274, nov. 2020. Available at: https://www.tandfonline.com/doi/abs/10.1080/09638199.2020.1847172?journalCode=rjte20. Accessed on: 23 nov. 2020.

LIU, F. et al. China's innovation policies: Evolution, institutional structure, and trajectory. Research Policy, v. 40, n. 7, p. 917-931, set. 2011. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0048733311000709. Accessed on: 22 nov. 2020.

MALPASS, D. The World Bank (IBRD - IDA), 1944. Home page. Available at: https://www.worldbank.org. Accessed on: 22 nov. 2020.

MARTÍN-DE CASTRO, G. Knowledge management and innovation in knowledge-based and high-tech industrial markets: The role of openness and absorptive capacity. Industrial Marketing Management, v. 47, p. 143-146, maio 2015. Available at: https://www.sciencedirect.com/science/article/abs/pii/S001985011500067X. Accessed on: 9 dez. 2020.

MENDONÇA, S.; PEREIRA, T. S.; GODINHO, M. M. Trademarks as an indicator of innovation and industrial change. Research Policy, v. 33, n. 9, p. 1385-1404, nov. 2004. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0048733304001222. Accessed on: 22 nov. 2020.

MOWERY, D. C.; ROSENBERG, N. Trajetórias da Inovação: a Mudança Tecnológica nos Estados Unidos da América no Século XX. [S.l.]: Editora da Unicamp, 2005.

MURPHY, E. Diffusion of Innovations: Family Planning in Developing Countries. Journal of Health Communication, v. 9, n. 1, p. 123-129, jan. 2004. Available at: https://pubmed.ncbi.nlm.nih.gov/14960408/. Accessed on: 17 nov. 2020.

NAUDÉ, W. Entrepreneurship, developing countries, and development economics: new approaches and insights. Small Business Economics, v. 34, n. 1, p. 1-12, jan. 2010. Available at: https://link.springer.com/article/10.1007/s11187-009-9198-2. Accessed on: 4 nov. 2020.

NJOROGE, E. ISO - International Organization for Standardization, 1946. Home page. Available at: https://www.iso.org/home.html. Accessed on: 30 nov. 2020.

OKUN, B. S. Innovation and Adaptation in Fertility Transition: Jewish Immigrants to Israel from Muslim North Africa and the Middle East. Population Studies, v. 51, n. 3, p. 317-335, nov. 1997. Available at: https://www.tandfonline.com/doi/abs/10.1080/0032472031000150086. Accessed on: 22 nov. 2020

OLIVEIRA, W. D. D. Comparação dos Algoritmos C4.5 e MLP Usados na Avaliação da Segurança Dinâmica e no Auxílio ao Controle Preventivo no Contexto da Estabilidade Transitória de Sistemas de Potência. p. 110, 2013.

OLUWATOBI, S. et al. Innovation in Africa: Why Institutions Matter. South African Journal of Economics, v. 83, n. 3, p. 390-410, set. 2015. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1111/saje.12071. Accessed on: 27 nov. 2020.

OMELCHENKO, N. A.; KAZBAN, E. P.; DROBOTENKO, O. N. The Information Aspect of State Management in the Context of Formation of the Global Innovation System. In: POPKVA, E. G.; SERGI, S. B. (orgs.). "Smart Tecnologies" for Society, State and Economy. Cham: Springer International Publishing, 2021. p. 903-909. Available at: https://link.springer.com/chapter/10.1007/978-3-030-59126-7_100. Accessed on: 10 dez. 2020.

PENROSE, E. A Teoria do Crescimento da Firma. [S.l.]: Editora Unicamp, 1959. PEREZ, J. M. J48Consolidated: class for generating a pruned or unpruned C45 consolidated tree, Versão 3.1. [S.l.]: WEKA, 2016. Available at: 65 https://weka.sourceforge.io/packageMetaData/J48Consolidated/3.1.html. Accessed on: 10 abr. 2021.

PRADHAN, R. P. et al. The innovation- growth link in OECD countries: Could other macroeconomic variables matter? Technology in Society, v. 51, p. 113-123, ago 2017. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0160791X1630032X. Accessed on: 6 nov. 2020.

PROKSCH, D. et al. National health innovation systems: Clustering the OECD countries by innovative output in healthcare using a multi indicator approach. Research Policy, v. 48, n. 1, p. 169-179, fev. 2019. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0048733318301914. Accessed on: 11 nov. 2020.

QUINLAN, J. R. Induction of decision trees. Machine Learning, v. 1, n. 1, p. 81-106, mar. 1986. Available at: https://link.springer.com/article/10.1007/BF00116251. Acesso em: 1 dez. 2020.

RIDER, G. ILOSTAT - International Labor Organization, 1996. Home page. Available at: https://ilostat.ilo.org/. Accessed on: 28 nov. 2020.

ROSENBERG, N. Por Dentro da Caixa Preta: Tecnologia e Economia. [S.I.]: Editora Unicamp, 1982. ROTHWELL, R. Successful industrial innovation: critical factors for the 1990s. R&D Management, v. 22, n. 3, p. 221-240, jul. 1992. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-9310.1992.tb00812.x. Accessed on: 4 dez. 2020.

RUST, G. et al. Triangulating on Success: Innovation, Public Health, Medical Care, and Cause-Specific US Mortality Rates Over a Half Century (1950-2000). American Journal of Public Health, v. 100, n. 1, p. 95-104, abr. 2010. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2837442/. Accessed on: 9 dez. 2020.

SCHNEIDER, M. R.; SCHULZE-BENTROP, C.; PAUNESCU, M. Mapping the Institutional Capital of High-Tech Firms: A Fuzzy-Set Analysis of Capitalist Variety and Export Performance. Journal of International Business Studies, v. 41, n. 2, p. 246-266, fev 2010. Available at: https://link.springer.com/article/10.1057/jibs.2009.36. Accessed on: 1 nov. 2020.

SCHUMPETER, J. A. Os Economistas: Schumpeter - A Teoria Do Desenvolvimento Econômico - Uma Investigação Sobre Lucros, Capital, Crédito, Juro E O Ciclo econômico. São Paulo: Nova Cultural, 1997. SCHWAB, K. World Economic Forum, 1971. Home page. Available at: https://www.weforum.org/. Accessed on: 6 dez. 2020.

SCHOOL OF COMPUTER ENGINEERING, SURANAREE UNIVERSITY OF TECHNOLOGY (SUT), THAILAND et al. A Study of Job Failure Prediction at Job Submit- State and Job Start-State in High-Performance Computing System: Using Decision Tree Algorithms. Journal of Advances in Information Technology, v. 12, n. 2, p. 84–92, 2021.

SHUKLA, J. B. et al. Modeling the effects of variable external influences and demographic processes on innovation diffusion. Nonlinear Analysis: Real World Applications, v. 13, n. 1, p. 186-196, fev. 2012. Available at: https://www.sciencedirect.com/science/article/abs/pii/S1468121811001854. Accessed on: 1 dez. 2020.

SIBIRSKAYA, E. V. et al. The monitoring of the subject and object of the economic activity population in the innovative sector. Life Science Journal, v. 11, p. 292-296. jan. 2014. Available at: https://www.researchgate.net/publication/291289743_The_monitoring_of_the_subject_and_object_of_the_economic_activity_population_in_the_innovative_sector Accessed on: 3 set. 2020.

SOUZA, C. B. D; Hora, H. R. M; AZEVEDO FILHO, E. T. Socioeconomic indicators and innovative countries associated with data mining evidence. SN Business & Economics, v.3, p. 47, 2023. Available at: https://link.springer.com/article/10.1007/s43546-022-00418-9. Accessed on: 23 nov. 2023.

TAALBI, J. What drives innovation? Evidence from economic history. Research Policy, v. 46, n. 8, p. 1437-1453, out. 2017. Available at: https://www.sciencedirect.com/science/article/pii/S004873331730104X?via%3Dihub. Accessed on: 20 nov. 2020.

TANG, D. WIPO - World Intellectual Property Organization, 1967. Home page. Available at: https://www.wipo.int/portal/en/index.html. Accessed on: 1 dez. 2020.

TASKIN, F.; ZAIM, O. Catching-up and innovation in high- and low-income countries. Economics Letters, v. 54, n. 1, p. 93-100, jan. 1997. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0165176597000049. Accessed on: 28 nov. 2020.

VAN DER GAAG, N.; DE BEER, J. From Demographic Dividend to Demographic Burden: The Impact of Population Ageing on Economic Growth in Europe. Tijdschrift voor economische en sociale geografie, v. 106, n. 1, p. 94-109, fev. 2015. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1111/tesg.12104. Accessed on: 6 nov. 2020.

VASIN, S.; GAMIDULLAEVA, L.; FINOGEEV, A. Managing stimulation of regional innovation subjects' interaction in the digital economy. International Journal of Economics and Business Administration, v. 7, n. 4, p. 295-306, out. 2019. Available at: https://www.ijeba.com/journal/344. Accessed on: 28 nov. 2020.

VASYLTSIV, T. et al. Economy's innovative technological competitiveness: Decomposition, methodic of analysis and priorities of public policy. Management Science Letters, v. 10, n. 13, p. 3173-3182, maio 2020. Available at: http://growingscience.com/beta/msl/3964- economys-innovative-technological-competitiveness-decomposition-methodic-of-analysisand-priorities-of-public-policy.html Accessed on 13 nov. 2020.

WADHWA, P.; MCCORMICK, M.; MUSTEEN, M. Technological innovation among internationality active SMEs in the Czech economy: Role of human and social capital of CEO. European Business Review, v. 29, n. 2, p. 164-180, 13 mar. 2017. Available at: https://www.researchgate.net/publication/314873940_Technological_innovation_among_internationality_active_SMEs_in_the_Czech_economy_Role_of_human_and_social_capital_of_CEO. Accessed on: 21 nov. 2020.

WEKA: Waikato Environment for Knowledge Analysis. Versão 3. Waikato: WEKA, 2020. Available at: https://www.cs.waikato.ac.nz/ml/weka/. Accessed on: 29 nov. 2020.

WANG, L. et al. What nurtures fourth industrial revolution? An investigation of economic and social determinants of technological innovation in advanced economies. Technological Forecasting and Social Change, v. 161, p. 1-7, dez. 2020. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0040162520311318. Accessed on: 11 nov. 2020.

WITTEN, I. H. et al. Algorithms. In: Data Mining. [s.l.] Elsevier, 2017. p. 91–160.

WONGLIMPIYARAT, J. Technological change of the energy innovation system: From oilbased to bio-based energy. Applied Energy, v. 87, n. 3, p. 749-755, mar. 2010. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0306261909003766. Accessed on: 27 nov. 2020.

YONG, L. UNIDO | United Nations Industrial Development Organization, 1966. Home page. Available at: https://www. unido.org/. Accessed on: 9 dez. 2020.

ZANG, L.; XIONG, F.; GAO, Y. Does governance efficiency matter for national innovative capacity? One tale from different countries. Technology Analysis & Strategic Management, v. 31, n. 2, p. 239-252,

jan. 2018. Available at: https://www.tandfonline.com/doi/abs/10.1080/09537325.2018.1493450. Accessed on: 9 dez. 2020.

ZEB, A.; IHSAN, A. Innovation and the entrepreneurial performance in women-owned small and medium-sized enterprises in Pakistan. Women's Studies International Forum, v. 79, p. 1-8, mar. 2020. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0277539519303668. Accessed on: 4 jan. 2021.

ZHU, K.; KRAEMER, K. L.; XU, S. The Process of Innovation Assimilation by Firms in Different Countries: A Technology Diffusion Perspective on E-Business. Management Science, v. 52, n. 10, p. 1557-1576, out. 2006. Available at: https://www.researchgate.net/publication/220534861_The_Process_of_Innovation_Assimilation_by_Firms_in_Different_Countries_A_Technology_Diffusion_Perspective_on_EBusiness. Accessed on: 8 jan. 2021.