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教育不平等對創新的影響

The Impact of Inequality in Education on Innovation

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摘要

本研究探討了不平等對教育和創新的影響，重點關注其對創新發展的影響。 該研究的目的是調查教育機會和質量的差異如何影響創新成果和技術進步。 通過對相關文獻和實證數據的綜合分析，本研究探討了不同背景下教育不平等阻礙或促進創新的機制。

該研究採用混合方法，將教育指標和創新指標的定量評估與創新和教育生態系統中關鍵利益相關者的文獻綜述的定性方法相結合。 研究結果表明，教育差距與創新績效之間存在密切聯繫，這意味著獲得高質量教育的不平等限制了人們學習創新所需信息和技能的能力。

我們這項研究的目的是強調包容性教育和立法的重要性，為所有人提供平等的機會，無論社會經濟狀況如何。 此外，它還強調了完美舉措的重要性，這些舉措真正有助於解決弱勢群體（如低調的少數族裔和貧困社區）所遇到的具體挑戰。這些發現可以為政策制定者、教育工作者和想要促進長期創新和經濟增長的教育工作者等利益相關者提供幫助。 社會可以通過解決教育不平等和保證公平獲得高質量教育來增強創新潛力、刺激技術進步並實現包容性社會經濟增長。

關鍵詞：教育機會、教育不平等、創新、包容性政策、優質教育、社會經濟發展

Abstract

This study examines the impact of inequality in education and innovation, focusing on its implications for innovation development. The objective of the research is to demonstrate how disparities in educational access and quality affect innovation outcomes and technological advancement. Our objective with this research it's to emphasizes the urgency of inclusive education policies and legislation that provide equal opportunities for all, regardless of socioeconomic situation. Furthermore, it underscores the significance of perfect initiatives that really help to solve specific challenges encountered by relegated groups such as understated minorities and underprivileged communities

The research adopts a mixed-methods approach, combining a quantitative evaluation of educational metrics and innovation indicators with a qualitative approach in the literature review of key stakeholders in the innovation and education ecosystem. The findings demonstrate a strong link between education disparity and innovation performance, implying that unequal access to high-quality education limits people's capacity to learn the information and skills needed to enable innovation.

The findings repeatedly show that high levels of educational inequality have a powerful and negative impact on innovation. This negative relationship remains stable in both the Ordinary Least Squares (OLS) and Random Effects models, indicating its long-term influence. Intriguingly, the Fixed Effects model deviated from this trend, indicating a non-significant correlation, implying a more nuanced understanding, maybe influenced by contextual variables worth further investigation.

These findings could be used by stakeholders like policymakers, and educators, who want to foster long-term innovation and economic growth. Therefore, societies can increase their potential for innovation, stimulate technological advances, and achieve inclusive socioeconomic growth by tackling educational inequality and guaranteeing fair access to high-quality education.

Keywords: access to education, education inequality, innovation, inclusive policies, quality education, socio-economic development,

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Chapter 1: Introduction

1.1 Motivation

Education is not only a fundamental human right but also plays an essential role in driving economic growth, fostering innovation, and societal development (Grant C. , 2017). As recognized in Article 26 of the Universal Declaration of Human Rights, “Everyone has the right to education.” Access to quality education lays the foundation for individuals to reach their full potential, and contribute to society not only in economic growth but also in innovation. Throughout history, it has been widely acknowledged that a well-educated population is indispensable for an affluent and thriving society. Countries around the world have recognized the significance of education as a catalyst for development, implementing policies and initiatives to improve educational systems and outcomes (OECD, 2016). However, the reality is that inequalities in education persist in many countries and regions around the world.

Inequality in education refers to disparities in access, quality, and opportunities for education among different social groups, such as gender, ethnicity, socioeconomic status, and geographical location. These inequalities can perpetuate social and economic divisions, hindering the development of human capital and stifling innovation. It is essential to address these disparities to ensure inclusive and equitable education systems that foster innovation and drive sustainable development.

As mentioned in the report “The Contribution of Education in Economic Growth” by (Grant C. , 2017), the relationship between education and economic growth has been well-established. Innovation, driven by education, has emerged as a critical driver of

economic growth and prosperity in today's knowledge-based economies. The transformative power of education in fueling innovation has been widely recognized and substantiated by empirical evidence that has demonstrated the positive impact of education on various economic indicators, such as GDP per capita, productivity, and employment rates (Woessmann, 2021). For instance, countries that have made substantial investments in education have witnessed significant economic advancements and improvements in living standards.

Furthermore, innovation has emerged as a key driver of economic growth in the modern era. Innovation encompasses the creation, adoption, and implementation of new ideas, technologies, and processes that lead to improved products, services, and productivity. It is a crucial factor in maintaining competitiveness in today's globalized economy (OECD, 2010). Well-educated individuals are more likely to have the knowledge, skills, and critical thinking abilities necessary to generate and apply innovative ideas. Countries with robust educational systems have been able to nurture a culture of innovation and entrepreneurship, leading to technological advancements, industrial progress, and economic prosperity (OECD, 2016). Some of the countries that have made significant strides in nurturing innovation and entrepreneurship implemented digital technologies into their education reform, emphasizing the development of critical thinking, problem-solving, and creativity that engage students in collaborative and project-based learning skills are Finland, South Korea, United States, and Singapore, countries that rank high in the innovation index.

The negative impact of education inequality on innovation can be attributed to various factors. When a significant portion of the population is deprived of quality education, their skills and talents remain untapped, hindering their ability to contribute to

innovative endeavors. Furthermore, limited access to educational resources and opportunities perpetuates social and economic inequalities, creating a barrier for marginalized individuals to engage in innovative activities (Grant S. , 2023).

Several nations have implemented various strategies and initiatives to solve these problems. Some have concentrated on distributing educational resources fairly, ensuring that all societal sectors have equal access to high-quality education. Others have taken initiatives to close the digital divide and supply neglected areas with technology infrastructure. To increase innovative capacity and lower educational inequality, policies that support inclusive education, lifelong learning, and skill development have proven essential.

1.2 Purpose

The purpose of this research is to demonstrate the impact of inequality in education on innovation, using panel data analysis, the study aims to examine how variations in educational inequality across countries influence the level of innovation within their respective economies. By analyzing the relationship between education inequality and innovation, the research seeks to uncover the potential mechanisms and pathways through which unequal access to education can hinder or promote innovative activities. The findings of this study will provide valuable insights into the importance of addressing education inequality as a means to foster a conductive environment for innovation. The research outcomes will contribute to evidence-based policy recommendations aimed at reducing educational disparities and promoting inclusive educational systems that stimulate innovation and drive economic growth.

1.3. Framework

This research will be divided into six chapters in order to analyze the impact of education in innovation, starting from a literature review in which we will go through education-innovation related concepts, to inequality as a barrier to achieve innovation and the respective performance of these variables in order to generate conclusions. Starting with Chapter 2, we review the existing literature on innovation, education, and inequality in education and how some authors describe each term, their application, and field study, and also discuss different perspectives of each term and its conceptualization. We explore the relationship between our field of study innovation, education, and inequality, and provide some examples of the impact of education on economic growth.

In Chapter 3, we examine the extent of inequality in education globally, analyzing some factors contributing to education inequality and provide some examples of different countries per region, and discuss the implications of education inequality on various aspects, including innovation. Chapter 4, analyzes the innovation performance at a global level, we analyze different indicators and measures of innovation, and discuss regional variations in innovation. In Chapter 5 we describe the methodology employed, sample, and data in our research, then we specify the variables used in our analysis.

Chapter 6 presents a descriptive statistics and correlation analysis of the variables, that discuss the regression results obtained from our analysis and describe the significance of each variable with our dependent variable. Finally, we summarize the key findings from your study, the implication of our findings, and the relation between innovation and inequality in education, and provide some suggestions for future research.

Chapter 2 Literature Review

2.1 Innovation

Innovation is known as a key driver for a country's economic growth, improvement of competitiveness, job creation, adaptation to technological changes, and enhancing social conditions and quality of life. The concept of innovation is often associated with a greater sense of purpose in human development, stemming from its ability to promote technological, social, and cultural change through creative and inventive capacity. Additionally, innovation has achieved a highly sought-after status as the key to success in economic growth and sustainability efforts worldwide (Edwatds-Schachter, 2018). In his finding, he also describes innovation as involving invention, novelty, and change, which collectively represent various features of the process and elements included, such as its actors, drivers and resources, inputs, activities and outcomes, value generation, structural and institutional context, as well as other contextual factors. It's important to note that all of these elements have undergone and continue to undergo significant transformations that challenge traditional definitions of innovation, particularly the notion of technological innovation.

According to Fagerberg, Martin, and Esben (2013), innovation is becoming increasingly recognized as a crucially important economic and social phenomenon that requires serious research attention. Companies focused on staying ahead of their competitors recognize that innovation is key to their future success. Politicians also prioritize innovation, as it is believed to be important for growth, welfare, and employment. Fagerberg (2019) defined innovation as the process of introducing new products, services, processes, or organizational forms that are novel to the organization or society. He also describes innovation as a complex and multidimensional

phenomenon, which can be analyzed from different perspectives such as technological, organizational, institutional, and social.

On the other hand, other theorists state that that the field of innovation is a rapidly growing and relatively new area within social sciences, encompassing various disciplines that examine the connections between economic, technological, organizational, and institutional transformations. One of the primary roles of entrepreneurs in private firms is to utilize existing resources to create "new combinations and new uses" or innovations. This can involve the introduction of novel products and processes, as well as innovative approaches to securing raw materials, exploring new markets, and implementing organizational changes (Castellacci, 2005).

Edwards-Schachter (2018) and Fageberg (2019) defined the different types of innovation as technological innovation, product innovation, process innovation, service innovation, business model innovation, disruptive innovation, radical innovation, design-driven innovation, social innovation, responsible innovation. For example, Technological innovation, is described by Schumpeter (1992) as the opening to foreign markets and organizational development. Scherer (2001) on the other hand, defines Technological innovation as the process of introducing new technologies into the realms of production and consumption. It involves identifying novel technological opportunities, mobilizing the necessary human and financial resources to transform these possibilities into practical products and processes, and maintaining the ongoing activities required for innovation. Theoretically, innovation can be defined at different levels: national, regional, and global:

2.1.1 National Level

Innovation at the national level varies depending on the innovation ecosystem of each country, some authors define national innovation system as follows:

The network of institutions in the public and private sectors whose activities and interactions initiate, import, modify, and diffuse new technologies. (Freeman, 1987)

"The elements and relationships which interact in the production, diffusion, and use of new, and economically useful, knowledge, and are either located within or rooted inside the borders of a nation-state". (Lundvall, 1992)

"The set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provide the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills, and artifacts which define new technologies" (Metcalfe, 1995).

These definitions conclude that innovation at the national level involves different actors including government, institutions, universities, and others, and then their interaction with the help that the innovation process succeeds or fails, the policy marker needs to find a balance to make sure that the actors have the appropriate knowledge to implement innovation.

The National Innovation System from the OECD (1997) implies that policymakers may find it advantageous to discover leverage areas for improving innovative performance and overall competitiveness by having a basic understanding of the national innovation system. The report also suggests that future studies will concentrate on enhancing the metrics used to map interactions in national invention systems as well as the connections to the inventiveness of businesses and nations.

Therefore, by recognizing and utilizing their innovation strengths, enhancing their innovation indicators, and adopting policies that improve their innovative performance and overall competitiveness, countries can attain their national innovation goals.

2.1.2 The Regional Level

Miroslav (2010) says that regional innovation strategies, in contrast to national-level plans, emphasize the importance of closeness between all participants and the potential for social capital creation. Geographic proximity, has the potential to produce competitive benefits in terms of engagement, education, skill access, and collaboration in business and development. You might think of regional economies as the hubs of human technical learning. By taking advantage of agglomeration effects, innovations are primarily seen in areas with high institutional or human capital concentration. Regional innovation strategies therefore frequently concentrate on the unique requirements and resources of a given region, whereas national-level initiatives are more general and wider. Notable examples at the regional level include the United States and China. In the United States, Silicon Valley in California and Massachusetts are known for fostering knowledge exchange and the creation of new ideas that promote innovation and development. In China, on the other hand, Zhongguancun Technology Park in Beijing is a hub for innovation and technology development in Asia.

2.1.3 Global Level

Choo and Park (2022) define that extended networks of actors outside of national borders are taken into account by the Global Innovation Systems hereafter, (GIS) Perspective, which varies from the traditional National Innovation Systems hereafter, (NIS) Perspective. While the NIS Perspective focuses on a national or regional

environment, the GIS Perspective takes into account innovation activities in a global setting. The authors contend that rather than analyzing innovation activities in a national or regional context, it is more suitable to do so in today's worldwide world.

International Cooperation and Collaboration; Innovation often requires global collaboration, especially in complex and costly research areas. Joint research projects, mobility of researchers, and R&D collaboration between countries can accelerate the pace of innovation and address global challenges. International cooperation allows for the sharing of knowledge, resources, and expertise, enabling countries to leverage each other's strengths and collectively tackle common problems. Collaborative efforts can lead to breakthroughs in various fields and promote the development of innovative solutions that have a global impact.

2.2. Knowledge Transfer

In many regions, universities and research centers play a significant role in knowledge and technology transfer to the business sector. Establishing strong links between academia and industry can drive regional innovation and promote economic growth. Through collaborations, partnerships, and technology transfer programs, academic institutions can share their research findings, expertise, and technological advancements with businesses, enabling them to apply and commercialize these innovations. This collaboration facilitates the flow of ideas, promotes the development of new products and services, and enhances the competitiveness of the regional economy (Samuel Ankrah, 2015).

The transfer of technology from innovative countries to those lagging can help bridge the gap in terms of innovative capacity. Technology transfer agreements and supportive

policies can facilitate the adoption of innovative technologies in developing and emerging countries. This transfer can occur through licensing agreements, joint ventures, or knowledge-sharing initiatives. By accessing advanced technologies, these countries can accelerate their innovation efforts, boost productivity, and drive economic development. Additionally, technology transfer can address pressing challenges in areas such as healthcare, energy, agriculture, and infrastructure, contributing to sustainable development on a global scale. (UNTACD, 2014)

Grossman and Elhanan explore the association between Innovation and Economics growth on a global scale with theoretical and empirical insights into the relation through which innovation influences economic outcomes and emphasizes the importance of innovation, saying that countries who foster innovation through efficiency policies and institutions tend to experience a higher level of economic growth and prosperity. (Grossman & Elhanan, 1991).

Among the theoretical models that Grossman used the Schumpeterian Growth model, emphasizes the role of innovation, highlighting how the introduction of new technologies using innovation, and increased competition, generates productivity gains, and long-term economic growth. (Grossman, 1991). Following, the growth model patterns Grossmann also analyzes the Endogenous Growth Model: This model explains the effects of innovation on productivity and influences the steady-state level of economic growth, exploring the different versions of the endogenous model, that emphasize the determinant of economic growth through the incorporation of innovation as an endogenous factor driven by others aspects such as human capital accumulation, R&D investment, and knowledge spillovers. (Grossman, 1991).

2.3 Education

Education is widely recognized as a catalyst for personal and societal advancement. According to Smith (2018), education empowers individuals by enhancing their cognitive abilities, expanding their horizons, and equipping them with essential skills for life and work. Additionally, Johnson (2016) argues that education fosters critical thinking, creativity, and problem-solving skills, enabling individuals to navigate complex challenges and contribute meaningfully to society. Education can be defined as a process of acquiring knowledge, skills, values, and attitudes through formal or informal means. According to the OECD (2022), education is related a wide range of benefits for individuals and society, because it is an important aspect of human development, as it not only enhances individuals' personal growth but also contributes to the economic and social development of a country, reducing poverty, gender inequality, and ensure the achievement of others sustainable factor to increase the development and innovation in a country (OECD, 2022).

In recent years, countries such as Singapore, South Korea, Finland, Russia, Taiwan, the United States of America, and Canada have demonstrated that their crucial factor for economic growth and innovation in their countries has been high quality and equal access to education.

2.4 Education is a Crucial Factor in Innovation

As stated by the OECD (2016) digital literacy and digital or technology skills are becoming more and more important as our society becomes more dependent on technology. Education plays an important role in providing individuals with the necessary skills, knowledge, and mindset to approach problems creatively and generate innovative solutions. One effective method of developing innovation skills is through

problem-based learning. According to Hoidn and Kärkkäinen (2014), this approach is highly effective in higher education settings. By presenting students with real-world challenges that require novel solutions, they are forced to think outside the box and use their creativity to come up with innovative ideas. Effective change management is also an important factor in driving progress in education. Fullan (1992) argues that change involves learning new ideas and things - it is about understanding something new while also applying it effectively. Educational institutions must embrace change if they wish to remain relevant and meet the evolving needs of learners. The Brookings Institution's Center for Universal Education underscores this need for change as well as the importance of innovation when it comes to advancing education globally (Winthrop et al.,). They argue that innovation can drive progress by introducing new approaches, technologies, or methods into educational practices.

Most of the economists accepted the idea that various types of education such as the three R's, vocational training, and higher education mold individuals to carry out particular tasks or duties or help him carry them out more successfully. The idea seems to be sound. It may be supported by the idea that education improves one's capacity for receiving, deciphering, and comprehending information as well as the idea that processing and interpreting information is essential for doing or learning to perform a variety of tasks. (Richard R Nelson, 1966). Education is a particular function required for great adaption to change, the more educated a manager is the quicker will he be to introduce new techniques of production. The hypothesis says that education speed up the process of technological diffusion, and educated people are good innovators. (Richard R Nelson, 1966). Therefore, we can conclude that education plays a fundamental role in innovation by enhancing human capital, increasing labor productivity, and promoting economic growth. It enables individuals to acquire

knowledge, skills, and critical thinking abilities necessary for generating and implementing innovative ideas. Moreover, education facilitates the diffusion and transmission of knowledge, which further contributes to innovation. (OECD, 2016).

Today, it is widely acknowledged that education, regardless of intrinsic talent, promotes innovation and technology and boosts economic expansion and productivity. The adoption of the technology that generates innovation depends on education, which is a crucial step in this process. (PATRINOS, 2023). The case for educational innovation is frequently presented in the broader perspective of how education and skill development contribute to successful innovation. A solid foundation of education and skills is necessary for effective innovation in economies and communities. If educational systems fall short in this regard, they will need to innovate on their own.

2.5 Successful Cases of Using Education to Enhance Innovation

Singapore

Singapore has transformed its economy from a low-wage manufacturing base to a knowledge-based economy, and education has played a key role in this transformation (Teo & Lee, 2019). During Lee Kuan Yew's government education was part of his priorities, with the program “Equal Education for All”, because he believe that education played an important role for employment, he not only focuses on academic education but also technical education and vocational training, and invest in education was part of one of the 4 phases that Singapore go throw to consider one of the most competitive economic in 2017-2018 and rank number 1 in education during 2007-2008 by the world Economics Forums in the Global Competitive Ranking (Aljunied, 2004).

The government of Singapore made different investments, first S$500 million not only to enchant scientific and qualified talent but also to fund lifelong learning, also to attract young people some scholarship programs were created. In the innovation field, the government made different investments one for S$140 million to enhance and implement new skills for those workers whose careers have been disappearing or replaced. A S$100 million for programs that promote innovation and creative thinking. And thinking again in the young resources and increase the innovative thinking and economic fields allotted S$6.3 billion. (Aljunied, 2004)

In 2009, the plan of Prime Minister Lee was reflected when Singapore made his debut in the Programmed for International Student Assessment (PISA) and was among the top performers in all subjects. In 2015, Singapore occupied first place in all three subjects:

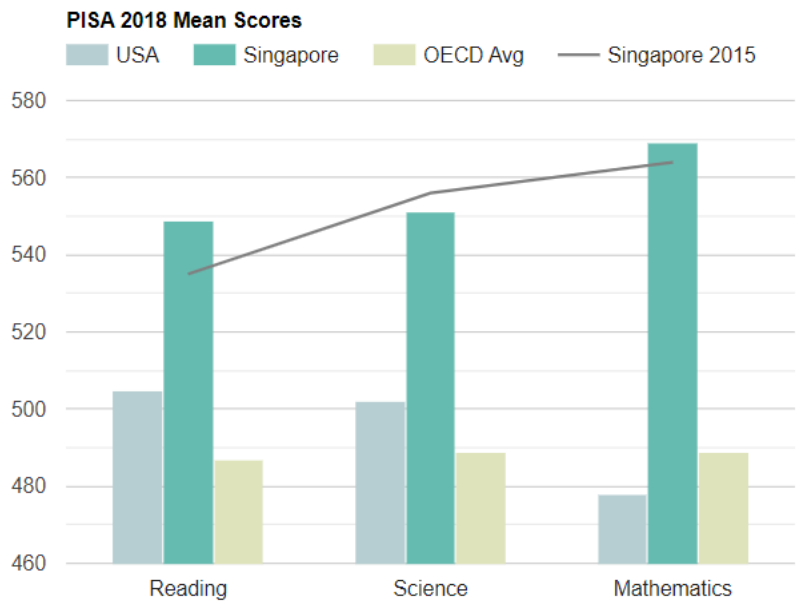


Figure 1: Pisa Mean Scores 2018

Sources: National Center on Education and the Economy

Russia:

has a long history of investing in education to promote development during the 20th century with its literacy campaign. During the 20th century in Europe, Russia had one of the highest literacy rates, with a population of around 60% to 70% that can't read or write (Clark, 1995). The Soviet educational development plan achieved compulsory primary education by 1934 and aimed to introduce secondary education for all. The Communist Party of the Soviet Union set objectives for eleven years of secondary education for all children by 1970, along with opportunities for employed individuals to acquire eight years of education. Soviet achievements include significant increases in primary school enrollments and expanding opportunities for secondary and higher education. The training of specialized workers also expanded, producing millions of specialists from educational establishments (U.S.S.R., 1962).

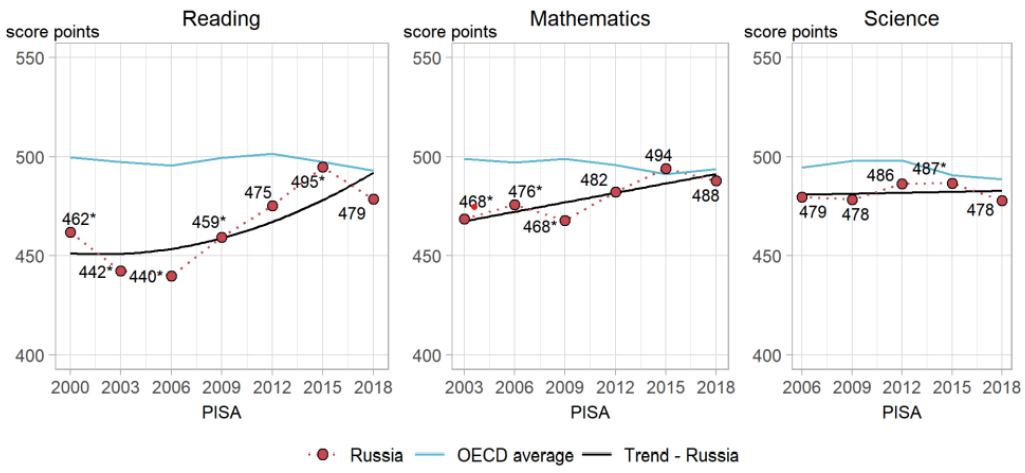
During the early years of Soviet industrial reconstruction, there was a belief that technology would solve most of the social problems. However, the difficulties encountered in training uneducated workers in technical methods led to the adoption of a new slogan, specialized workers are the solution to all problems. Consequently, the training of specialized workers expanded at educational establishments between 1930 and 1940. Although the war slowed down this process, it resumed and developed further during the peaceful years between 1950 and 1960. From 1918 to 1960, higher educational establishments alone produced 4,781,000 specialists, while secondary technical schools produced 7,744,000, resulting in a total of 12,525,000 specialists, of whom 6,755,000 (54%) graduated in the last decade. (U.S.S.R., 1962)

The significant achievements in public education in the Soviet Union have played a crucial role in enhancing the efficiency of production and driving economic

development. The active participation of Soviet workers, who consider themselves masters rather than servants of production, has contributed to their eagerness to improve their qualifications through education. With millions of workers striving to increase output rates, a multitude of talented inventors and rationalizers emerge each year. The success can be attributed to the high regard for science in the Soviet Union, where it is considered an essential guide for progress and development (U.S.S.R., 1962).

The close connection between the cultural revolution and economic advancement in the Soviet Union is evident. Investments in public education yield substantial returns as they align with the cultural interests of the laboring masses and meet the requirements of economic development. It has become increasingly evident that the cultural factor, represented by education and knowledge, is economically productive and profitable. This recognition underscores the significance of education in driving economic success and progress in the Soviet Union (U.S.S.R., 1962). In recent years Russia is still betting on education, in 2008 was established the Russia Education Aid for Development (READ) program, it's an example of the concerted effort to have a quality education, not only focusing on students but also on the quality and skills of the teachers.

The three main objectives of the READ program are: "1) Provide support on student assessment to developing countries, through the READ Trust Fund; 2) Develop the capacity of Russia as an emerging donor in education, through the READ Reimbursable Advisory Service; and 3) Facilitate Russia's international development in education. The result of this program for Russia can be reflected in different international assessments, moreover in the most recent PISA assessment results in 2018. (Bank W. , 2019)



Notes:*indicates mean-performance estimates that are statistically significantly above or below PISA 2018 estimates for Russia.
The blue line indicates the average mean performance across OECD countries with valid data in all PISA assessments. The red dotted line indicates mean performance in Russia. The black line represents a trend line for Russia (line of best fit).
Source: OECD, PISA 2018 Database, Tables I. B1.10, I. B1.11 and I. B1.12.

Figure 2: PISA assessment results in 2018

Source: PISA results from 2003 to 2018

2.6 The Impact of Education on Economic Growth

There are plenty of studies about education on economic growth, in the paper "Does schooling create growth?" (Bils, 2000) examined the relationship between education (measured by average years of schooling) and economic growth to check if exists a causal effect on economic growth and contribute to higher output per capita. They use cross-country panel data covering a large number of countries over several decades and employ a growth regression framework to analyze the relationship between education and economic growth while controlling for other factors such as initial income, investment rates, and population growth.

Some of the theoretical pieces of literature accentuate some instruments where education affects economic growth: (Kirsty Newman, 2020). Firstly, education plays a role in enhancing the inherent human capital of the workforce, leading to increased labor productivity and facilitating transitional growth towards a higher equilibrium level of output. This concept aligns with augmented neoclassical growth theories, as

discussed by Mankiw et al. (1992). Secondly, education contributes to boosting the innovative capacity of the economy. The acquisition of new knowledge about technologies, products, and processes stimulates growth, as highlighted in theories of endogenous growth. This perspective is explored by Lucas (1988), Romer (1990), and Aghion and Howitt (1998). Thirdly, education enables the dissemination and transfer of knowledge necessary for comprehending and effectively implementing new information and technologies developed by others. This knowledge diffusion fosters economic growth, as suggested by Nelson and Phelps (1966) and Benhabib and Spiegel (1994).

2.7 Inequality in Education

Inequality in education can be defined as the disparities and differences in educational opportunities and access, as well as the quality of education received by individuals, groups, or regions, "According to the report "Equity and Quality in Education Supporting Disadvantaged Students and Schools", educational inequality can stem from a variety of factors including socio-demographic aspects, race, and ethnicity, socioeconomic levels, gender, geographical location, disabilities, lack of educational policies, resource gaps, education quality, discrimination, and segregation."(OECD, 2012). The multifaceted problem of educational inequality has implications for both individual and collective development, as well as at the state and regional levels. These disparities can arise from various factors and resources, such as socio-demographic aspects, race, and ethnicity, socioeconomic levels, gender, geographical location, disabilities, lack of educational policies, resource gaps, education quality, discrimination, and segregation.

Education can manifest itself in various ways and due to various factors, as mentioned earlier. Some of the most important factors include, and some dimensions that contribute to educational inequality, such as those described below:

Quality Disparities:

Quality disparities in education highlight variations in the educational experiences and opportunities available to different individuals or groups. Factors such as teacher qualifications, infrastructure, curriculum, teaching methods, learning materials, and classroom sizes contribute to differences in educational quality. Disadvantaged communities often face challenges in accessing schools with adequate resources and highly qualified teachers, leading to lower-quality education (OECD, 2012).

Resource Disparities

Resource disparities in education encompass unequal distribution of resources, including funding, facilities, technology, libraries, and extracurricular activities. Schools in economically disadvantaged areas often struggle with limited resources, resulting in inadequate infrastructure, outdated materials, and fewer opportunities for enrichment. Such disparities can perpetuate educational inequalities and hinder the development of student's skills and abilities (OECD, 2012).

Outcome Disparities:

Outcome disparities in education reflect differences in academic achievement, graduation rates, dropout rates, and educational attainment. Socioeconomic factors, institutional biases, and unequal opportunities contribute to variations in educational outcomes. Disadvantaged individuals and marginalized communities often face lower

achievement levels and reduced opportunities for post-secondary education or meaningful employment (OECD, 2012).

According to the American Psychology Association (2017) Socioeconomic status (SES) includes not just money but also the level of education, financial stability, and self-perceived social standing and class. A person's socioeconomic position might include aspects of their quality of life as well as the possibilities and privileges that are available to them in society. In particular, poverty is defined by numerous physical and psychosocial stressors rather than being caused by a single reason. Furthermore, a wide range of outcomes across the life span, including physical and mental health, are consistently and accurately predicted by SES. SES is thus relevant to study, practice, education, and advocacy in all fields of behavioral and social science.

Inadequate educational policies: The policies implemented by governments often fail to be appropriate and have an impact on educational inequality. Lack of investment leads to inadequate and unequal infrastructure throughout the region. This can be seen in many Latin American and African countries, where rural areas often lack proper infrastructure for imparting knowledge. Similarly, in higher education, many individuals have to relocate to metropolitan areas to attend university. Inadequate educational policies are also linked to corruption and poor governance, as funds are often misappropriated and transparency is lacking. This results in resources allocated for education being used for different purposes. (Barbara Bruns, 2019)

In Haiti, despite a significant percentage of schools being privately owned, the infrastructure conditions are very poor. Many schools use churches (31%), houses (16%), and temporary shelters (9%) as facilities. The conditions of these schools are

extremely inadequate, lacking proper ventilation due to the absence of windows and walls. Additionally, they suffer from a lack of electricity (91%) and clean water (45%), especially in rural areas. (HOYT, 2010)

Socioeconomic factors: Inequality in education is closely linked to socioeconomic differences/income inequality, as they can affect access to quality education. This socioeconomic gap makes it impossible for many families to afford school fees, educational materials, or additional services charged by educational institutions. It also prevents their children from being able to move to a different city to receive better education or even study in another country. (Weis, 2017)

Gender disparities: Globally, girls and women often face inequalities in access to education compared to boys and men. These disparities can be related to cultural practices, social norms, stereotypical gender roles, and economic barriers. As the World Bank points out, gender inequality is reflected in the labor force participation gap, which is particularly pronounced in regions such as South Asia and the Middle East, and North Africa. In these regions, female labor force participation rates are as low as 24% and 20%, respectively, compared to countries in Latin America or East Asia, where female participation rates exceed 50% in both regions. (World Bank, 2022)

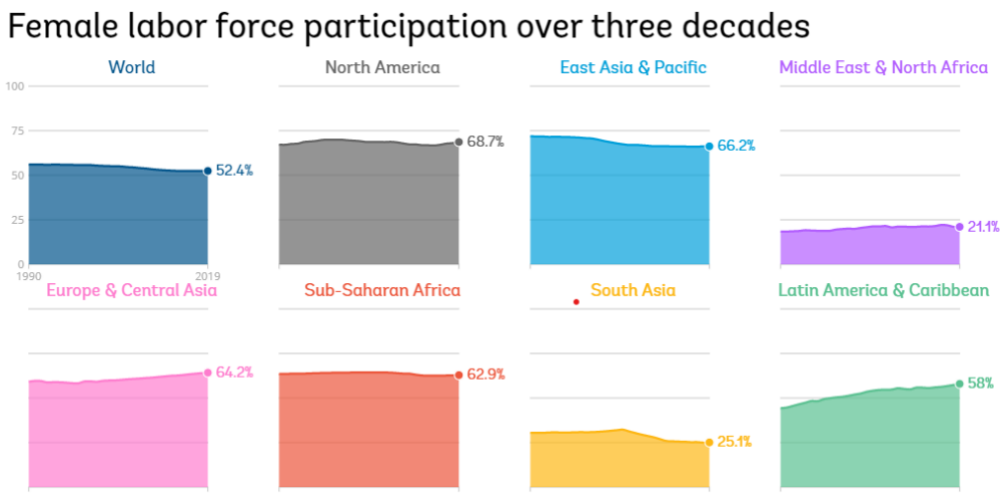


Figure 3: Female Labor force participation over three decades

Source: International Labor Organization (ILO). Data retrieved from World Bank Gender Data Portal

Discrimination and segregation: Another factor that can create inequalities in access to education is the denial of certain groups' access to quality education based on their ethnic origin, social status, race, or religion. In many countries, students belonging to racial or ethnic minorities face additional obstacles, including discrimination, limited access to educational resources, and often a lack of representation in the curriculum. Disparities in education between different ethnic and racial groups can be observed in countries such as Mexico, Chile, Colombia, and Peru. (UNESCO, 2023)

Geographical location: It can also represent disparities in education. Rural or remote communities often face challenges in accessing educational institutions, educational resources, and trained teachers, which limits the educational opportunities for residents in those areas.

Barriers to disability: People with disabilities often face inequalities in education due to a lack of physical accessibility and adapted resources. Physical barriers, lack of support, and discrimination can limit access to inclusive and quality education.

Chapter 3: Inequality in Education and Innovation in the World

3.1 Inequality in Education in the World

Inequality in Education has multiple causes that vary depending on the context of each country and region, most of them are the consequences or policies that don't consider all the factors of the societies and just focus on a specific group. We divided the countries per region in order to analyze the differences in inequality of each region, just taking 2-3 countries of each region or studying in a general way some of the countries in each region, in some continents we analyze the top one according to the Global Innovation Index, the one in the middle and the least innovative country, this way we can compared if there is a common factor between some of them and inquire the inequality.

3.2 North America & Latin America

Ranking	country	hdicode	Continenet	Ranking	country	hdicode	Continenet
3	United States of America	Very High	America	68	Uruguay	Very High	America
16	Canada	Very High	America	71	Jamaica	High	America
37	Peru	High	America	75	Panama	Very High	America
48	Mexico	High	America	79	Argentina	Very High	America
49	Paraguay	High	America	89	Dominican Republic	High	America
53	Chile	Very High	America	91	El Salvador	Medium	America
55	Costa Rica	Very High	America	97	Ecuador	High	America
61	Brazil	High	America	100	Honduras	Medium	America
64	Trinidad and Tobago	Very High	America	102	Bolivia	Medium	America
67	Colombia	High	America	103	Guatemala	Medium	America

Table 1: List of countries in North America & Latin America

Source: Author's elaboration with the list of countries including in the research

3.2.1 The United States

In the United States, educational inequality exists along racial, socioeconomic, and geographic lines. Describing the inequality in the racial sense we can mention the inequality in the African-American and other minority students, In the socioeconomic line the different opportunities according to socioeconomic status, and in the geographic line the government investment is nearly 10% more than in the poorest areas, and with 3 of 1 ratio and disparities in school funding, resources, and access to quality education contribute to inequality. Segregation and the achievement gap are also significant factors (Weiss, 2017). According to the research made by (Joanna Yingxin Tan, 2022) data shows that the overall level of education acquired by men and women of all races in the U.S. has increased. The Hispanic population, meanwhile, keeps lagging behind. The types of institutions used to measure education quality show minimal improvement over the past few years. While students of dominant races are overrepresented in private non-profit colleges, minority students make up a larger proportion of students there. Differences in access to education and disparities in educational quality among the United States can be demonstrated particularly in the differences in schooling resources between women, other minorities, and white people. Therefore, the impact of educational inequality in the United States reinforces existing social inequalities, leading to unequal opportunities for academic achievement, employment prospects, and overall life outcomes.

3.2.2 Brazil

Brazil experiences inequality in education due to unequal access to quality schools, educational resources, and educational opportunities based on socioeconomic status and geographic location. In socioeconomic status there is a disparity among those

students who can afford a private school and those who need to attend a public school, even though the government invested in the 2015 designated 5.5% of the GDP compared with previous years that was only 4.5%, however, this invested in not well reflected and is when the geographical location is taken in consideration as a fact of inequality, an example for a study of the social protection organization mention that the geographical inequality can be reflected with the percentage of student that finishes the tertiary education in the Distrito federal that reach 33%, compared with one of the poorest state in Brazil as is Maranhão where only an 8% of the adults completed the tertiary education (Thomas Bearman, 2019). The impact of the educational inequality reinforces social inequality and perpetuates cycles of poverty. Therefore, it hampers social mobility, limits opportunities for disadvantaged individuals, and hinders the country's overall development.

3.2.3 Guatemala

Guatemala is the less innovative country in the region, ranking 103 in the general ranking and in the last position in the region of the Global Innovation Ranking. Most of the inequalities in education in Guatemala are related to the rural areas and indigenous people. According to the National Institute of Statistics (INE) Guatemala's indigenous population represents 44%, that are located particularly in the western highlands. The rural departments north and west of Guatemala City have the largest populations, especially Alta Verapaz, Sololá, Totonicapán, and Quiché.

One of the primary issues is the lack of educational resources and infrastructure in many indigenous areas. Remote communities often lack schools, well-trained teachers, and adequate learning materials. This results in limited opportunities for indigenous

children to receive a quality education (Affairs). Language barriers also contribute to the educational gap. Many indigenous communities primarily speak Mayan languages, while the education system predominantly uses Spanish as the medium of instruction. This language gap makes it difficult for indigenous students to fully engage with the curriculum, leading to lower educational outcomes and reduced opportunities for innovation. (López, 2009)

The socioeconomic divide in education is also widened. Indigenous peoples in Guatemala frequently have greater rates of poverty and less access to essential services like clean water and healthcare. Children who are indigenous have significant obstacles to frequent attendance at school and academic success (Edwards, 2002). The innovation process in Guatemala is significantly impacted by educational disparity. Diverse viewpoints, ideas, and experiences foster innovation. The nation loses out on the distinctive perspectives and contributions that indigenous groups can offer by denying quality education to a sizable portion of the population and just given to them their own resources, focusing in their heritage instead of teach and shows about new technologies, and taking out of their culture, instead of mix their own culture and teach new skills outside their own world. (Schielmann, 204)

3.3. Europe

Ranking	country	hdicode	Continenet
1	Switzerland	Very High	Europe
2	Sweden	Very High	Europe
6	Denmark	Very High	Europe
7	Finland	Very High	Europe
9	Germany	Very High	Europe
10	Portugal	Very High	Europe
11	France	Very High	Europe
12	Israel	Very High	Europe
14	Ireland	Very High	Europe
17	Lithuania	Very High	Europe
18	Austria	Very High	Europe
20	Iceland	Very High	Europe
21	Belgium	Very High	Europe
23	Czech Republic	Very High	Europe
24	Estonia	Very High	Europe
27	Italy	Very High	Europe
28	Cyprus	Very High	Europe
29	Spain	Very High	Europe
31	Slovenia	Very High	Europe
33	Ukraine	High	Europe
34	Hungary	Very High	Europe
36	Bulgaria	High	Europe
38	Slovakia	Very High	Europe
40	Croatia	Very High	Europe
42	Greece	Very High	Europe
45	Romania	Very High	Europe
46	Russian Federation	Very High	Europe
52	Serbia	Very High	Europe
54	Malta	Very High	Europe
62	Georgia	Very High	Europe
63	Belarus	Very High	Europe
69	Poland	Very High	Europe
73	Bosnia and Herzegovina	High	Europe
74	Moldova, Republic of	High	Europe
82	Albania	High	Europe
86	Latvia	Very High	Europe
87	United Kingdom	Very High	Europe
101	Montenegro	Very High	Europe
104	Norway	Very High	Europe
108	Macedonia	High	Europe
110	Turkey	Very High	Europe
111	Luxembourg	Very High	Europe
113	Netherlands	Very High	Europe

Table 2: List of countries in Europe

Source: Author's elaboration with the list of countries from the innovation index list

For Europe we are only analyze two countries and describe some of the disparities that affects most of the continent:

3.3.1. Switzerland:

Switzerland faces challenges in providing equitable access to quality education. In the following paragraph we are going to describe some of the education inequalities that Switzerland face, from their causes and which are the more affected groups by this issue. Some of the challenges are more related to their families background as: as parents' education, occupation and income, also, the resources that the school provide including teacher and quality of the curriculum, the infrastructure, schedule of class the resources of schools such as the quality of the teachers, size of school and autonomy, and the hours that students spent at school also contribute to educational inequality, also she mentioned that one of the important factors that contribute to educational inequality is the structure of the educational system. (Stadelmann-Steffen, 2012)

Socioeconomic status is one of the main reasons for the educational disparity in Switzerland that is discussed. One of the studies (OECD, 2020) has demonstrated that children from low-income families experience larger obstacles to receiving a high-quality education because of budgetary limitations. As a result, there are gaps in academic attainment and future chances due to limited access to educational resources, extracurricular activities, and tutoring.

Gender also plays a significant role in education inequality. While Switzerland has made progress in promoting gender equality in education, significant gender disparities exist in the distribution of tertiary applicants across academic specialties. In most OECD nations, women are disproportionately underrepresented in a number of STEM fields, including engineering and mathematics. In 2019, women made up 20% of new hires in computer and communication technology and 26% of those in engineering, manufacturing, and construction. Women made up 13% of new students in computer and communication technologies and 19% of new entrants in engineering, manufacturing, and construction programs in Switzerland. They made up 72% of the newcomers to the field of education, which has historically been dominated by women. In Switzerland, men make up 38% of educators at all levels of education, as opposed to an OECD average of 30%. (OECD, 2021)

3.3.2. Romania

Romania faces educational inequality primarily due to disparities in access to quality education between urban and rural areas. Limited resources, outdated infrastructure, and a lack of qualified teachers in rural schools contribute to inequality.

The Impact of educational inequality in Romania perpetuates regional disparities, affecting the life chances and future prospects of students from rural areas. It can result in limited access to higher education, employment opportunities, and socioeconomic mobility

3.4. Africa

Ranking	country	hdicode	Continenet
19	Niger	Low	Africa
25	Namibia	Medium	Africa
32	Madagascar	Low	Africa
43	Tanzania, United Republic of	Low	Africa
44	Uganda	Low	Africa
51	Mali	Low	Africa
57	Mauritius	Very High	Africa
59	South Africa	High	Africa
83	Nigeria	Low	Africa
85	Kenya	Medium	Africa
88	Botswana	Medium	Africa
90	Rwanda	Low	Africa

Ranking	country	hdicode	Continenet
93	Morocco	Medium	africa
94	Egypt	High	Africa
96	Togo	Low	Africa
99	Senegal	Low	Africa
105	Ghana	Medium	Africa
109	Cote d'Ivoire	Medium	Africa
114	Burkina Faso	Low	Africa
115	Cameroon	Medium	Africa
117	Zambia	Medium	Africa
118	Malawi	Low	Africa
121	Benin	Low	Africa
123	Guinea	Low	Africa

Table 3: List of countries in Africa

Source: Author's elaboration

South Africa faces significant disparities in access to quality education, particularly along racial and socioeconomic lines. Unequal distribution of resources, such as school infrastructure and qualified teachers, contributes to educational inequality. According to a report from the World Bank, the educational system of South Africa is bimodal (Group, 2018), this can be reflected in the test scores, schools that provide education to whites and Indians have better results compared with schools that provide educations to black and colored students, the first one scores can be compared to schools in development and the second one to schools in most of the poorest countries in Africa.

3.5. Asia

Ranking	country	hdicode	Continenet
8	Singapore	Very High	Asia & Pacific
13	China	High	Asia & Pacific
15	Japan	Very High	Asia & Pacific
22	Australia	Very High	Oceania
26	Malaysia	Very High	Asia & Pacific
30	Philippines	Medium	Asia & Pacific
35	Kyrgyzstan	Medium	Asia & Pacific
41	Vietnam	High	Asia & Pacific
47	India	Medium	Asia & Pacific
56	New Zealand	Very High	Asia & Pacific
60	Armenia	High	Asia
70	Brunei Darussalam	Very High	Asia & Pacific

Ranking	country	hdicode	Continenet
76	Kazakhstan	Very High	Asia & Pacific
77	Korea, Republic of	Very High	Asia & Pacific
81	Azerbaijan	High	Asia & Pacific
84	Indonesia	High	Asia & Pacific
95	Pakistan	Low	Asia & Pacific
98	Sri Lanka	High	Asia & Pacific
106	Tajikistan	Medium	Asia & Pacific
107	Cambodia	Medium	Asia & Pacific
112	Bangladesh	Medium	Asia & Pacific
119	Mongolia	High	Asia & Pacific
120	Thailand	Very High	Asia & Pacific
122	Nepal	Medium	Asia & Pacific

Table 4: List of countries in Asia

Source: Author's elaboration

Consideration must be given to numerous issues and indicators connected to access, quality, and educational results in several Asian nations with higher levels of educational inequality. Even while no single factor may yield a clear ranking, certain Asian nations have had a difficult time correcting educational disparity. Here are a few nations where education disparity has drawn attention:

India experiences educational inequality due to various factors, including disparities based on socioeconomic status, gender, caste, and geographic location. Limited access to quality schools, teacher shortages, and cultural biases contribute to inequality.

The Impact of educational inequality in India perpetuates social and economic disparities. It hampers social mobility, limits opportunities for marginalized groups, and poses challenges to the country's overall development and innovation potential. (Mausam Kumar Garg, 2022).

Here are some of the main inequality factors in India according to Mausam Kumar (2022)

In India, educational inequality is assessed by examining the distribution of the population based on their education level, using methods such as the education Gini coefficient and the Lorenz curve.

Several factors contribute to educational inequality in India, including gender disparities, disparities based on place of residence, and disparities among different social and religious groups.

Gender-based educational gaps persist in India, with noticeable differences between males and females in terms of educational opportunities and attainment.

In 2018, the bottom 27% of the population had access to only about 2% of the total accumulated years of schooling, while the top 3% of the population had nearly 7% of the total accumulated years of schooling.

A significant disparity in education existed in 2007, where the bottom one-third of the population had no formal education.

Over the past 11 years, educational inequality has shown a considerable decrease in some states of India. However, in other states, the reduction in educational gaps has been less pronounced.

The North-Eastern states of India have consistently demonstrated better performance in maintaining higher education levels and narrowing educational gaps compared to other regions.

Pakistan also experiences disparities in education, with significant differences in enrollment rates, learning outcomes, and access to education between different socio-economic groups and regions. The absence of educational institutions, particularly in rural regions, is one of the major causes of educational disparity in Pakistan. As a result, a sizable percentage of the population is prevented from advancing in their schooling. In Pakistan, cultural norms and gender roles may also contribute to educational inequities since they may hinder female mobility and place a greater emphasis on male learning. (SHAH, 2018)

Bangladesh: Even while access to education in Bangladesh has significantly improved, there are still inequalities, particularly between urban and rural areas and between different income levels. The National Strategy for Accelerated Poverty Reduction in Bangladesh (Government of Bangladesh (GOB) 2005) makes clear the importance of education policy and lists it as one of four strategic building blocks for promoting economic growth, reducing poverty quickly, and fostering social development. In the field of education, enhancing equity as well as quality is a top priority. There are programs for underprivileged and underprivileged children who have either failed conventional schooling or are unable to attend it. The maintenance of a primary stipends program for underprivileged kids and the implementation of school nutrition programs are further tactics for tackling education disparity. (Al-Samarrai, 2008)

What might government education spending patterns look like if government policy and aspirations to reduce inequality were effectively implemented? Spending should, at the very least, be dispersed evenly among those who are of school age. For instance, it would be reasonable to assume that disadvantaged children would get at least half of the resources if they made up 50% of the population of primary school age. However,

the poor are going to need a larger share of the available resources if government goals for enhanced equity in outcomes are to be completely met. Because of inadequate pre-primary education funding as well as poor early nutrition, disadvantaged students sometimes start primary school at a substantial disadvantage. This initial disadvantage is exacerbated during primary school because there is typically little financial and intellectual support. Greater government expenditure on the poor could potentially close the achievement gap in education by, for instance, implementing targeted cash transfer programs, reducing class sizes, promoting catch-up learning, and/or improving school inputs. (Al-Samarrai, 2008)

Philippines: Despite efforts to improve access to education, the Philippines continues to face disparities in educational opportunities, particularly between urban and rural areas and among marginalized groups. To highlight one limitation, only children from middle- or high-income families can access a good basic education. Only they have access to opportunities for a top-notch education, such as the free instruction offered by State Universities and Colleges (SUCs). Concerns have been raised about the Philippines' educational system's quality. Several obstacles still exist despite efforts to raise curricular standards and instructional strategies. The lack of trained teachers, especially in rural regions, is a serious problem (Abinales & Amoroso, 2017). The results of students' learning are hampered by this scarcity and are affected by the quality of instruction.

3.6 Innovation in the World

There are different indicators and methodologies used to calculate the level of innovation in a country.

3.6.1. Innovation Index

Innovation Indexes: International organizations such as the World Intellectual Property Organization (WIPO) and the European Commission have developed and classified countries based on innovation indexes. Examples include the Global Innovation Index (GII) and the Bloomberg Innovation Index. These indexes evaluate various aspects such as institutional environment, investment in R&D, collaboration between businesses and universities, and technology transfer. According to the GII (Global Innovation Index 2021, 2021), the most innovative countries are Switzerland, Sweden, the United States, the United Kingdom, and the Netherlands. Some indicators used in these indexes include Research and development expenditure, Patents and intellectual property registration, infrastructure, education, etc. (Index, 2022)

3.6.2 The Global Innovation Index

In order to give a thorough and trustworthy evaluation of nations' innovation capacities, Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO) collaborated to develop the Global Innovation Index. The concept for the GII came from the realization that innovation is essential for promoting social progress, economic development, and international competitiveness. In order to improve their innovation ecosystems, policymakers and business leaders throughout the world

searched for a tool that could unbiasedly measure and benchmark countries' performance in terms of innovation.

The Global innovation index measure and compare the level of innovation in different countries (WIPO, 2022). It provides a comprehensive evaluation of the factors driving innovation in terms of the institutional environment, human resources, research and development (R&D), infrastructure, innovation outcomes, and other relevant indicators. Although there are different methodologies and approaches to calculating the Innovation Index, here is a general description of the common components and steps used in its calculation. There are several crucial steps involved in creating an innovation index. The first step is to carefully choose the indicators that will best represent the various facets of innovation. R&D spending, patent filings, scientific publications, industry-university partnerships, and education spending are a few examples of these indicators (GII, 2021). Each indicator is selected in accordance with the index's specific goals and its applicability to innovation. To enable accurate comparisons between nations, the data must be standardized after the indicators have been chosen. The indicators are put on a single scale by the normalization process, which assures that they may have varied measurement scales. This makes it possible to evaluate innovation performance fairly and accurately.

The creation of an innovation index entails the selection of pertinent indicators, data normalization, index calculation, index analysis, and outcome comparison. This methodical technique makes it possible to evaluate innovation performance thoroughly and to make useful comparisons between nations. Policymakers and stakeholders can make well-informed decisions to encourage and promote innovation-driven growth by using an innovation index to acquire insightful information about the advantages and

disadvantages of a nation's innovation ecosystem. (Global Innovation Index 2021, 2021).

The GII provides valuable insights into the innovation landscape, facilitating policymakers, business leaders, and researchers in understanding the innovation potential of countries and identifying best practices for fostering innovation.

The main objectives of the Global Innovation Index according to the information on their website are to:

1. Measure and benchmark innovation performance: The GII aims to quantify and compare the innovation capabilities of countries to foster healthy competition and collaboration in innovation-driven activities.

2. Identify areas of strength and areas for improvement: By evaluating various innovation indicators, the GII helps countries identify their relative strengths and weaknesses in different aspects of innovation, guiding them in formulating targeted strategies for improvement.

3. Promote policy dialogue and knowledge exchange: The GII report encourages policy discussions on innovation-related issues and facilitates the exchange of knowledge, best practices, and policies among countries.

The GII uses a comprehensive framework to assess the innovation performance of countries. The main criteria and indicators considered in the GII ranking include:

- Institutions: This criterion assesses how well a nation's corporate, political, and regulatory environments encourage and support innovation.

- Human Capital and Research: It evaluates the quality and quantity of the nation's human capital, taking into account factors including educational attainment, research facilities, and academic output.

- Infrastructure: This criterion examines the country's physical and digital infrastructure, which contributes to the ease of conducting business and fostering innovation.

- Market Sophistication: It measures the level of market competition, demand, and business sophistication, indicating the receptiveness of the market to innovative products and services.

- Business Sophistication: This criterion assesses the capabilities of domestic enterprises in terms of their business models, processes, and entrepreneurship.

- Knowledge and Technology Outputs: It evaluates the impact and diffusion of knowledge and technology through patents, trademarks, and creative outputs.

- Creative Outputs: This criterion considers intangible assets such as creative goods, services, and entertainment, reflecting a country's ability to generate and monetize creative ideas.

Countries are selected for the GII based on data availability, reliability, and consistency across the chosen indicators. The GII aims to cover a diverse group of countries from different regions and income levels to provide a global perspective on innovation capabilities. (WIPO, 2022)

The GII ranking is determined by calculating a composite score based on the performance of each country across the criteria and indicators. The GII report also includes detailed analysis and case studies of high-performing countries, offering insights into successful innovation policies and strategies. (WIPO, 2021)

The Global Innovation Index has become a valuable tool for policymakers and stakeholders in gauging the innovation capacity of countries and formulating evidence-based policies to enhance their innovation ecosystems. By promoting an environment of knowledge sharing and best practices, the GII plays a vital role in advancing global innovation and sustainable development.

3.6.3. Innovation Performance in the World

Innovation is unique to each country and involves various important factors, such as universities, research centers, public and governmental policies, investments in education, and innovation as a whole. Globally, certain countries stand out for their innovative capacity. According to the latest innovation report, Sweden, the United States, and Switzerland are among the top performers. Other countries worth mentioning for their innovation capabilities include Germany, Japan, South Korea, Singapore, and Taiwan. According to the innovation report, these countries make significant investments in research and development, as well as scientific and

technological infrastructure, which are fundamental for growth and the creation of innovative companies.

According to the global innovation index the following countries are the most innovative countries during 2021.

Figure 4: Global innovation index 2021

Source: Global Innovation Index 2022

From the 2017 to the 2017 there are some countries in the following image, we can observe the country displacements from the year 2017 to 2021. It is noticeable that certain countries remain in the same position, while others undergo changes

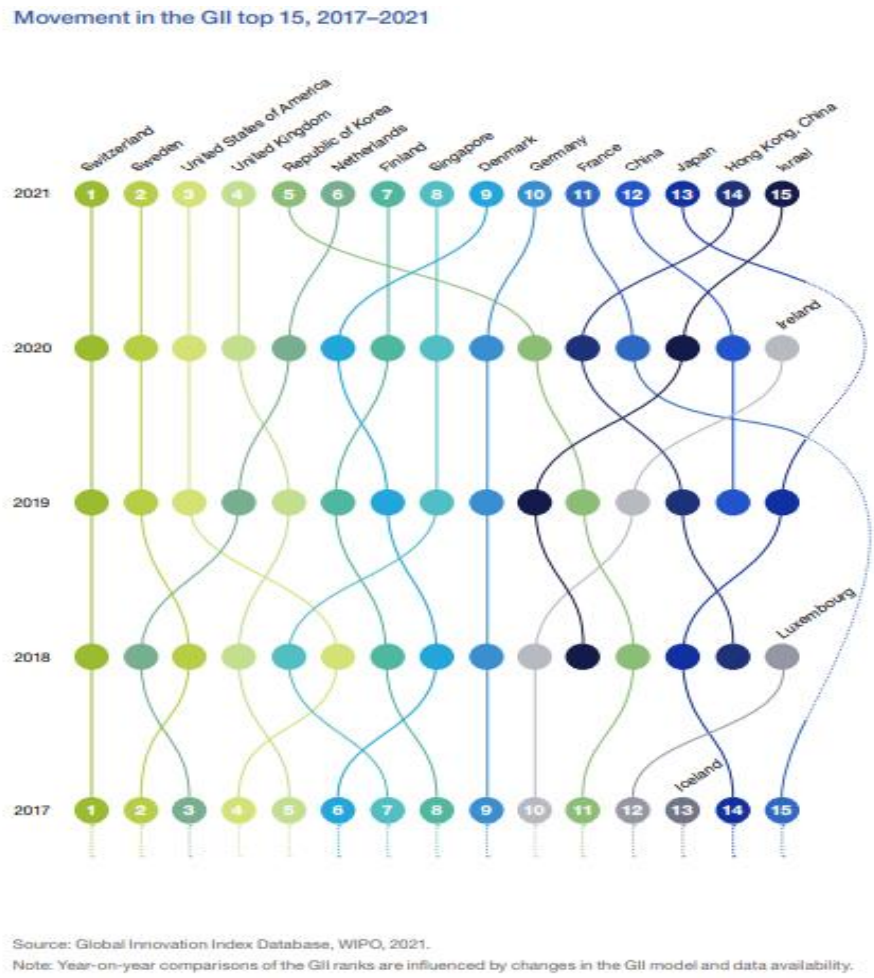


Figure 5: Movement in the Global Innovation Index

From 2017 to 2021, Switzerland is the only country that has maintained its position (first position) during these 5 years, followed by Sweden, which moved from the third place to the second place in the same period as Switzerland. The Republic of Korea went from the 11th position in 2017 to being part of the top 5, occupying the fifth position in 2021.

3.7 Innovation Inequalities

Innovation inequality stands as a compelling facet of the global socio-economic landscape, reflecting the uneven distribution of resources, opportunities, and capabilities to foster innovation across different continents and nations. This phenomenon encompasses the disparities in generating, assimilating, and capitalizing on innovative ideas and technological advancements.

In fostering equal access to the benefits of frontier technology, developing countries face three major challenges according to the Technology and Innovation Report (2021):

• Income poverty: Many people in developing countries, particularly those in rural areas, cannot afford modern goods or services. The constraints in this scenario are not technological, but rather economic and social.

• Digital divide - Many cutting-edge technologies rely on consistent, high-speed fixed Internet connections, while over half of the world's population remains disconnected. Many underdeveloped countries lack basic digital infrastructure, and Internet costs are prohibitively expensive for the majority of their citizens.

• Skill shortage - Basic and standard skills in developing nations are 10 to 20 percentage points lower than in wealthy countries. Many cutting-edge technologies necessitate at least literacy and numeracy skills. Other technologies necessitate digital proficiency.

An examination of innovation inequality across continents reveals distinctive patterns, often shaped by historical, economic, and infrastructural factors.

3.7.1 Africa

Due to various challenges, innovation inequality is significant in Africa. Across the continent, countries face a lack of access to high-quality education, research facilities, and finance. As a result, the capacity for innovation varies greatly. Notably, South Africa stands out for having a relatively sophisticated innovation scene. This is due to the existence of research-intensive universities, investments in technology parks, and attempts to foster entrepreneurial ecosystems. (Ekekwe, 2015) Countries such as Sudan and Mali, on the other hand, face huge innovation gaps due to factors such as continuous conflicts, inadequate education systems, and restricted technological infrastructure.

3.7.2 Asia

Asia showcases a diverse range of innovation capacities, often aligned with economic prosperity and investment in research and development. Japan and South Korea exemplify high innovation capabilities, underscored by their prolific patent activity and advanced technology sectors. These nations' consistent commitment to R&D has led to breakthroughs in various industries. On the flip side, countries such as Afghanistan confront substantial innovation challenges, stemming from persistent conflict, inadequate infrastructure, and lack of investment in knowledge creation.

3.7.3 Europe

In Europe, innovation inequality assumes various shades across the continent. Western European nations, endowed with robust economies, tend to exhibit well-established innovation ecosystems. Germany is a quintessential example, renowned for its emphasis on scientific research, engineering, and technological innovation. Conversely, certain Eastern European countries face innovation disparities rooted in historical legacies and limited access to research funding. The fragmentation of research capabilities across Eastern Europe has implications for the continent's overall innovation landscape.

Europe's economic development has been varied, with some regions enjoying quicker growth and technological improvements than others. This historical disparity has exacerbated inequities in innovation throughout the continent. (Rodríguez-Pose, 2012) Automation and digitalization, for example, have played a crucial impact in establishing innovation inequality in Europe. These advances frequently necessitate specialized skills and resources, resulting in a concentration of innovation in specific regions or industries. (Kitzmüller, 2021). Inequities in educational opportunity and skill development contribute to inequities in innovation. Individuals and areas are limited in their ability to participate in innovative activities due to unequal access to quality education and training programs. (Kitzmüller, 2021)

3.7.4 America

North America, epitomized by the United States and Canada, is renowned for its advanced innovation capacities. The Silicon Valley phenomenon stands as a testament to the region's prowess in nurturing technological innovation. Nevertheless, within this innovation hub, disparities persist. Underserved communities often lack access to educational resources, technological infrastructure, and networking opportunities, leading to localized innovation gaps that warrant attention.

In South America, innovation capacities span a spectrum influenced by economic conditions and governmental support. Brazil demonstrates notable innovation potential, with advancements in agriculture, energy, and digital technology. This trajectory stems from strategic investments in research and development. However, countries grappling with economic instability, such as Venezuela, face severe innovation challenges. Socio-economic constraints hamper access to education, research facilities, and funding, contributing to innovation inequalities.

3.7.5 Oceania

Oceania presents a mix of innovation capabilities, often associated with the economic strength of nations. Australia boasts a robust innovation ecosystem, driven by research-intensive universities and public-private partnerships. Conversely, smaller Pacific Island nations struggle with innovation inequality due to limited access to educational resources, research facilities, and technology infrastructure. The divergence in innovation capacities mirrors the broader economic heterogeneity in the region.

Innovation inequality, an intricate interplay of historical, economic, and socio-political factors, underscores the dynamic nature of global development. Disparities in innovation capacities across continents and countries reflect the challenges of aligning resources and opportunities. Recognizing these inequalities is pivotal for formulating inclusive strategies to bridge the innovation gap, thereby fostering sustainable growth, technological advancement, and global progress.

3.7.6 Examples of Innovation Inequality

India vs. Singapore: India has a large pool of skilled professionals and a growing technology industry. However, there's significant inequality in innovation capabilities between urban centers and rural areas. In contrast, Singapore has invested heavily in research and development, resulting in a highly advanced technological landscape.

Sweden vs. Ukraine: Sweden has a strong innovation culture with investments in research, education, and technology. This is reflected in its numerous successful startups and technological advancements. On the other hand, Ukraine faces challenges due to political instability and limited funding for research and development.

Kenya vs. South Korea: Kenya has shown innovation potential through its mobile money platform, M-Pesa. However, limited access to quality education and resources hinders further innovation. In contrast, South Korea's government-led initiatives have propelled it to the forefront of technological innovation, with global brands like Samsung leading the way.

These examples highlight the complex interplay of factors that contribute to innovation inequality. These factors include education systems, research and development funding, political stability, access to technology, and overall economic development.

3.8 Education Inequality and Innovation during COVID-19

3.8.1 Education Inequalities During Covid-19

Global education systems have been severely impacted by the COVID-19 epidemic, which has resulted in school closures and disruptions to instruction to control the spread of the disease. The transition to online learning and school closures brings difficulties not only for students but also teacher, and parents, and have brought attention to the disparities in access to technology and internet connectivity that already exist. It may be difficult for students from low-income families or those who live in remote locations to completely engage in online learning because they lack the required technology and dependable internet access. (Seble Tadesse1, 2020)

School closures have reportedly had an impact on about 1.3 billion pupils in 186 countries, according to UNESCO. And as a result, the gaps are already getting worse. In countries with strong levels of digital adoption, the government has tried to fast replace traditional school attendance with online learning while also looking for ways to lessen the disruption's detrimental effects on academic achievement. However, as not every home has one, even if a household has one working computer, it might need to be shared among the family members. Some teachers are guiding courses in the UK where up to one-third of the kids could not have access to a digital device or suitable internet connectivity, as the Sutton Trust recently pointed out. (Adetunji, 2020)

Differences in several dimensions and sub-dimensions, such as socioeconomic learning inequality, non-financial parental support, financial parental resources, attendance at school, students' digital skills, non-cognitive skills, and cognitive skills, time spent at home with children, at-home digital resources, a suitable home learning environment, nutrition, teachers' digital skills, and the cost of after-school learning activities are likely to be the primary causes of inequality. Additionally, the crisis could widen the success gap between native-born children and migrant pupils, and students with impairments run the risk of falling far behind. (Di Pietro, 2020)

The pandemic has also impacted the quality of the learning experience, with challenges such as poor learning spaces at home, lack of fieldwork and access to laboratories, and increased stress among students. Students from disadvantaged backgrounds are more likely to face difficulties in accessing resources and support for remote learning

Although continuing the education system through distance learning is a viable option, doing so in developing nations is challenging due to the high number of parents who did not complete their education and the absence of the infrastructures, computers, radios, and televisions required for distance learning. Successful distant education requires basic infrastructure, including access to computers and the internet. For all pupils in impoverished nations, this is not a given. (Zhang, 2022).

Teachers and staff should also be conversant with online teaching tools. Technology-related issues and a lack of infrastructure are a difficulty for teachers. Some private schools may only pay half the staff members' salaries, while other institutions may not pay them at all. Since many pupils do not have access to the

necessary technology at home, COVID-19 has an impact on disadvantaged households. Due to the physical closure of the school and the adoption of online learning, students now spend less time studying and are less motivated to learn. (Di Pietro, 2020).

In South Africa, COVID-19 has exacerbated inequalities in education where poverty is a significant issue, with more than the 50% of children living below the poverty line and more predominant in rural areas, and has pushed an additional 4 million people into extreme poverty. Access to technology and the internet is limited, with only about 10.4% of households having internet access at home. The lockdown has exacerbated existing disparities in the education system, resulting in two distinct education systems: one with impoverished, primarily black students, overcrowding, and insufficient resources, and the other with well-resourced schools and technology-mediated distant learning. Poor educational outcomes are exacerbated by four systemic restrictions, including insufficient teacher content understanding and pedagogical competencies. Teachers with limited digital skills and older age profiles struggle to adjust to the demands of remote learning. Students with disabilities, as well as those who live in rural areas, have limited access to support structures. (Rubeena Parker, 2020)

Any proposed innovations in education must consider and address these deep-seated inequalities and constraints to avoid further entrenching disadvantages for the most vulnerable.

The COVID-19 pandemic has posed enormous issues for corporations, schools, and the way kids learn. It has revealed existing educational gaps and deepened the digital divide. However, it has also generated chances for innovation and the use of technology in education. To address educational inequities, it is critical to offer equitable access to

technology, support students from underprivileged backgrounds, and stimulate cooperation and creativity in remote learning environments. The pandemic's lessons can help shape future policies to encourage inclusive education and innovation.

3.7.2 Innovation during COVID-19

Innovation was impacted by the COVID-19 pandemic between 2020 and 2021. The forced business closures brought on by the pandemic have caused an unprecedented disruption in trade across the majority of industry sectors. Even if a lot of the repercussions might last forever, the pandemic has accelerated technology and digital change by a long shot. Businesses have advanced the digitization of their internal operations and supply-chain interactions by three to four years, according to a McKinsey Global Survey of CEOs. (Laura LaBerge, 2022)

The necessity for a robust and sustained recovery has also been brought to light by the COVID-19 epidemic. Returning to 'business as usual' and environmentally irresponsible methods is not an option if the economic recovery from the COVID-19 catastrophe is to be long-lasting and resilient. The pandemic has massively accelerated some pre-existing trends, in particular digitalization, and has set in motion waves of change with a wide range of possible trajectories

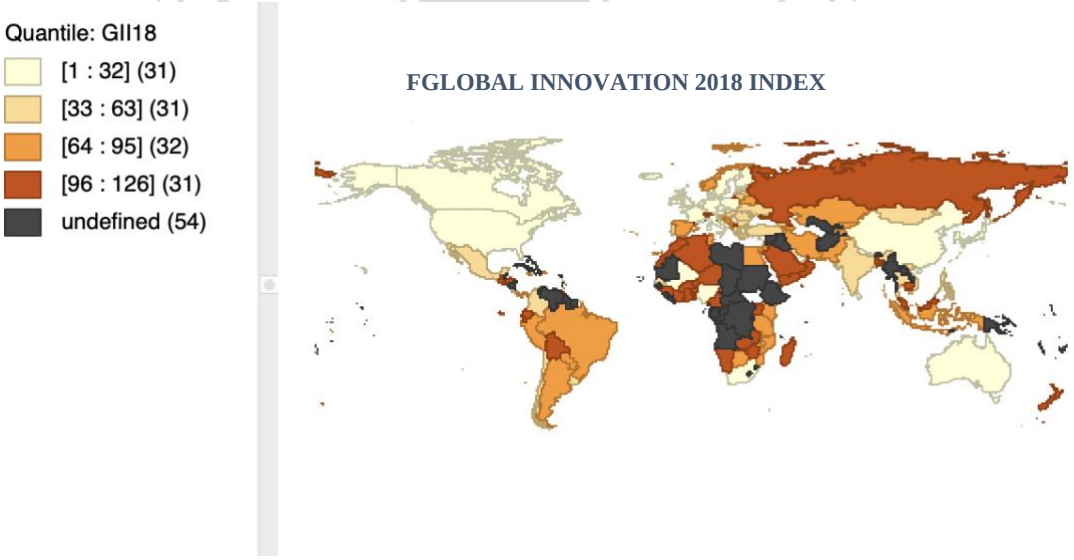
But in many nations, a shortage of human capital can stifle innovation. For instance, the poor state of science, technology, and innovation in the least Developed Countries (LDCs) is due in part to low levels of investment in research and development, low enrolment rates in higher education, and a shortage of trained personnel.

A lack of competent workers and researchers may impede the development of novel concepts and technologies in nations with low levels of human capital, setting off a

vicious cycle of underinvestment in research and development and social and economic inequality.

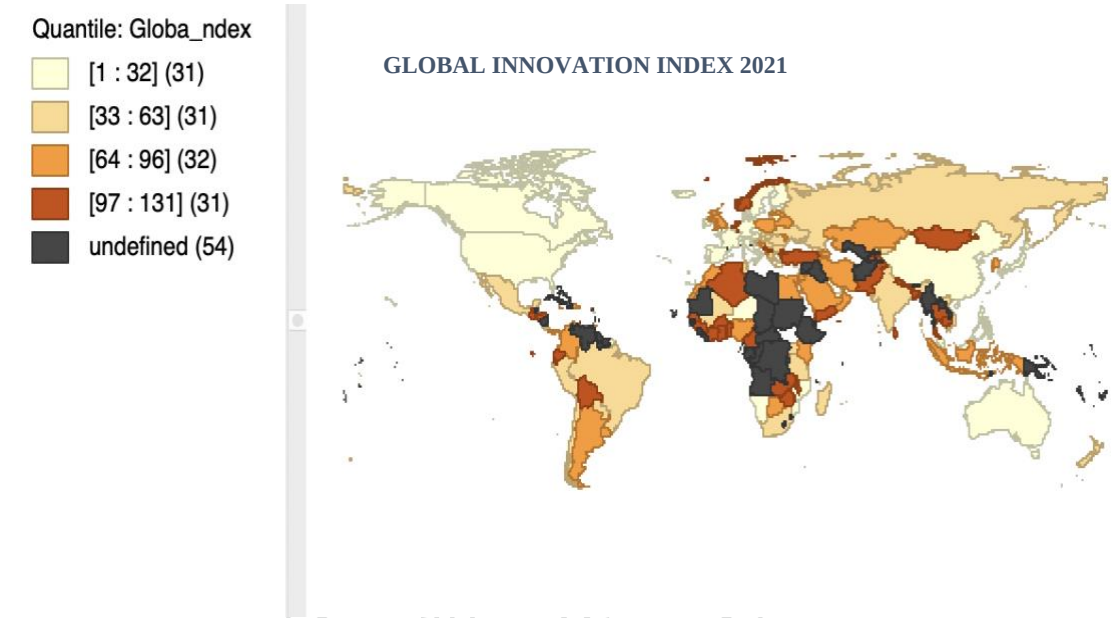
The maps show that there is little variation in the values of educational inequality and innovation scores between the years 2018 and 2021. This suggests that there might not have been significant changes in educational inequality and innovation during these time periods.

The quantile map shows that the values for educational inequality are relatively stable across all four years, with the majority of countries falling within the same quantile ranges. This consistency in values might indicate that there were no major shifts in the distribution of educational inequality among the countries studied.



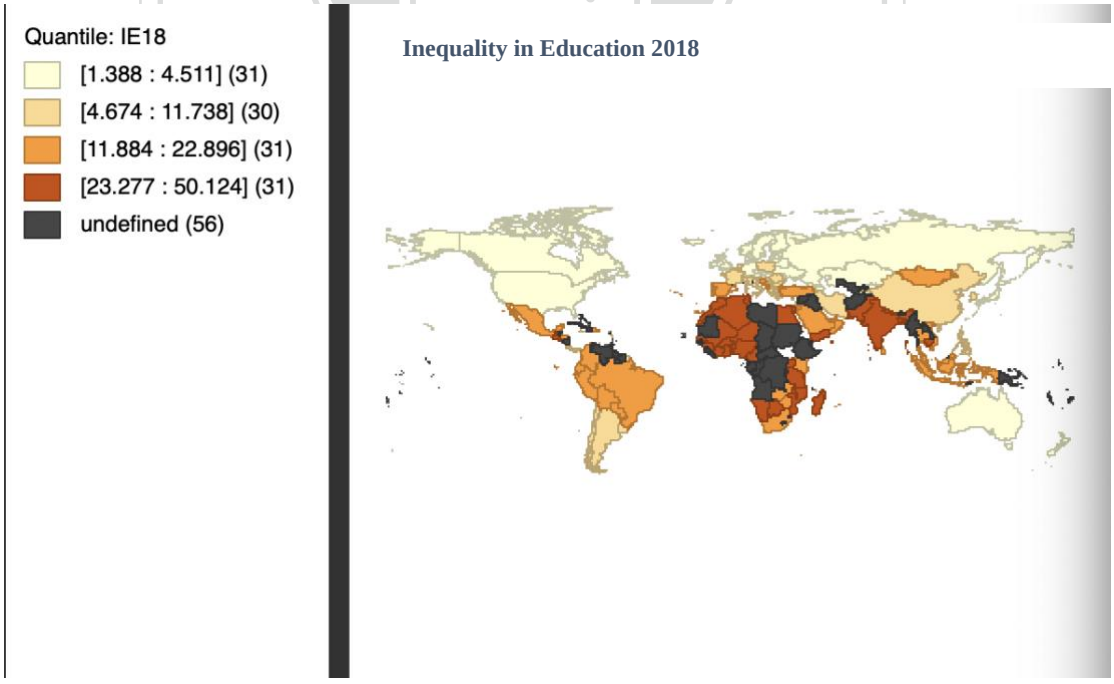
Figures 6: Map of Global Innovation Index 2018

Source: author's elaboration with data source from the innovation index of 2018 and human development index 2018



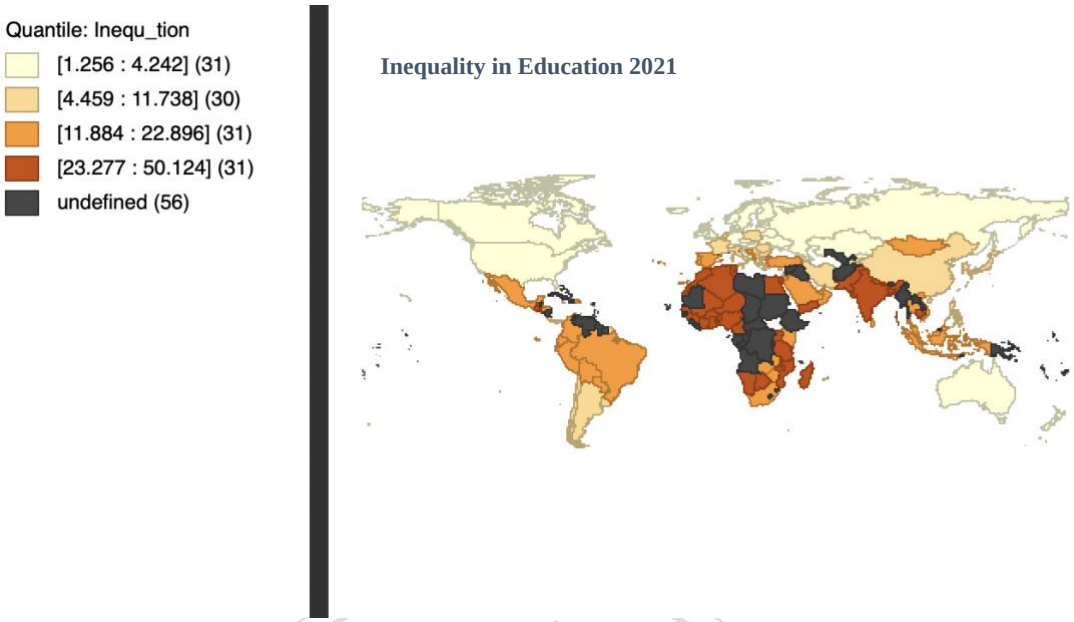
Figures 7: Map of Global Innovation Index 2021

Source: author's elaboration with data source from the innovation index of 2018 and human development index 2018



Figures 8: Inequality in Education 2018

Source: author's elaboration with data source from the innovation index of 2018-2021and human development index 2018-2021



Figures 9: Inequality in Education 2021

Source: author's elaboration with data source from the innovation index of 2018-2021and human development index 2018-2021

Chapter 4: Methodology

4.1 Data Source and Sample

The Human Development Index and the Global Innovation Index data were the primary sources of information for this research. These resources offer thorough and well-known measurements of innovation and human growth worldwide.

The 124 countries that make up the study's sample span a wide range of geographical regions with a good representation and developmental stages included. In order to ensure that the results could be applied to a variety of circumstances and not only focuses on countries with the same characteristics, find below the 124 countries that were included, they show the current ranking in the Global Innovation Index of 2021, there are some countries that were not included because of the lack of information in the others variables in gray color.

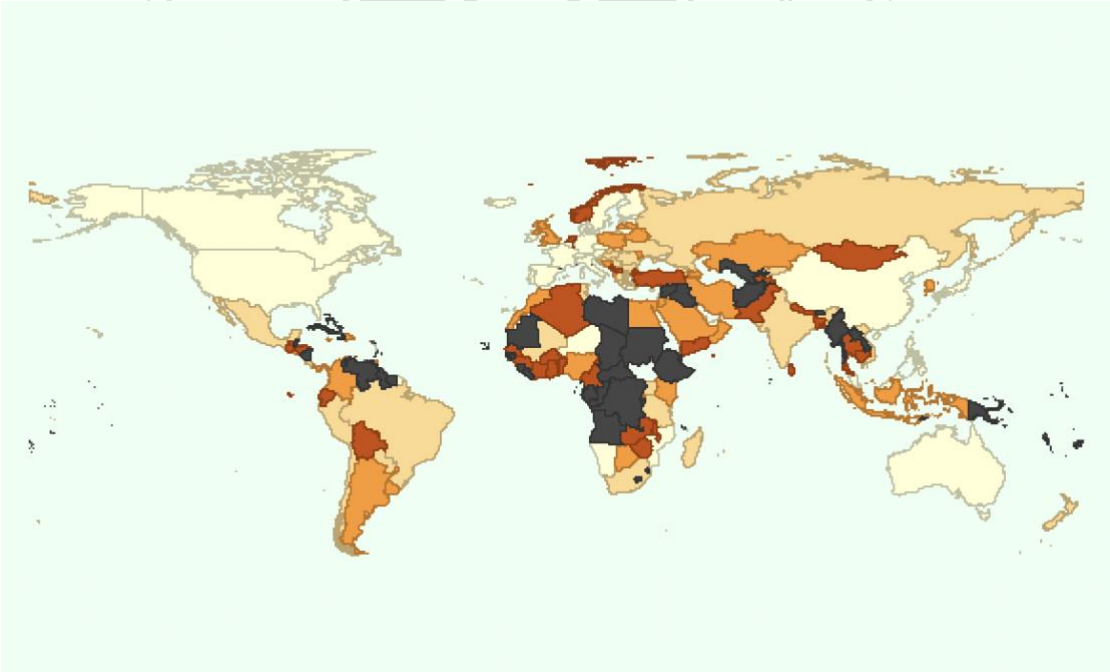


Figure 10: Map including all the countries

Source: author's elaboration with data source from the innovation index of 2021

Countries	GII Ranking	Countries	GII Ranking	Countries	GII Ranking	Countries	GII Ranking
Switzerland	1	United Arab Emirates	33	Uruguay	65	Pakistan	99
Sweden	2	Hungary	34	Saudi Arabia	66	Namibia	100
United States of America	3	Bulgaria	35	Colombia	67	Guatemala	101
United Kingdom	4	Malaysia	36	Qatar	68	Rwanda	102
Korea, Republic of	5	Slovakia	37	Armenia	69	Tajikistan	103
Netherlands	6	Latvia	38	Peru	70	Bolivia	104
Finland	7	Lithuania	39	Tunisia	71	Senegal	105
Singapore	8	Poland	40	Kuwait	72	Botswana	106
Denmark	9	Turkey	41	Argentina	73	Malawi	107
Germany	10	Croatia	42	Jamaica	74	Honduras	108
France	11	Thailand	43	Bosnia and Herzegovina	75	Cambodia	109
China	12	Vietnam	44	Oman	76	Madagascar	110
Japan	13	Russian Federation	45	Morocco	77	Nepal	111
Hong Kong (China)	14	India	46	Bahrain	78	Ghana	112
Israel	15	Greece	47	Kazakhstan	79	Zimbabwe	113
Canada	16	Romania	48	Azerbaijan	80	Cote d'Ivoire	114
Iceland	17	Ukraine	49	Jordan	81	Burkina Faso	115
Austria	18	Montenegro	50	Brunei Darussalam	82	Bangladesh	116
Ireland	19	Philippines	51	Panama	83	Nigeria	118
Norway	20	Mauritius	52	Albania	84	Uganda	119
Estonia	21	Chile	53	Kenya	85	Algeria	120
Belgium	22	Serbia	54	Indonesia	87	Zambia	121
Luxembourg	23	Mexico	55	Paraguay	88	Mozambique	122
Czech Republic	24	Costa Rica	56	Tanzania, United Republic	90	Cameroon	123
Australia	25	Brazil	57	Ecuador	91	Mali	124
New Zealand	26	Mongolia	58	Lebanon	92	Togo	125
Malta	27	Macedonia	59	Dominican Republic	93	Benin	128
Cyprus	28	Iran, Islamic Republic of	60	Egypt	94	Niger	129
Italy	29	South Africa	61	Sri Lanka	95	Guinea	130
Spain	30	Belarus	62	El Salvador	96	Yemen	131
Portugal	31	Georgia	63	Trinidad and Tobago	97		
Slovenia	32	Moldova, Republic of	64	Kyrgyzstan	98		

Table 5: General list of all the countries including in the research

Source: Author's elaboration with data from Global Innovation Index 2021.

In the tablet are included the countries with the ranking of the Global Innovation Index, however, we only use 124 countries, that will support our research, the GII tracks several aspects of innovation, such as financial investments in R&D, the number of patents filed, and the output of new knowledge and technology. This score offers useful perceptions into the performance and capacity for innovation of nations, allowing for an analysis of the effect of education on innovation in its entirety.

The United Nations Development Programme (UNDP) created the Human Development Index (HDI), which includes metrics including income, health, and education levels (UNDP, 2022). The HDI offers a thorough assessment of human development, reflecting the general state of affairs and standard of living in many nations. This study considers the larger socioeconomic context in which innovation

happens by including the HDI in the analysis, it is crucial to remember that the data from these sources go through stringent data collection procedures and are frequently updated and checked. The usage of these well-known indexes guarantees the accuracy and legitimacy of the data utilized in this study effort.

The sample's 124 countries provide it a strong international representation for analyzing the global connection between innovation and inequality in education, in conclusion, 124 countries' worth of data from the Innovation Index and the Human Development Index were used to create this study project. By combining different data sources, it is possible to examine the connection between inequality in education and innovation in great detail, giving important insights into worldwide patterns and trends.

4.2 Variables

4.2.1. Dependent Variables

Global Innovation Index: Due to its robust methodology and the combination of different indicators such as research investment, education, patents, human development, and industry-academia collaboration, the Innovation Index provides a high and comprehensive range of precise and holistic measurement of innovation at the regional or country level and it is widely recognized globally (WIPO, GLOBAL INNOVATION INDEX CONCEPTUAL FRAMEWORK, 2019).

The dependent variable of innovation is represented in the form of a ranking from 1 to 124, indicating that the country ranked number 1 is the less innovative, and so on until the country ranked 122 as the most innovative, the ranking was made this way in order that the readers can understand the result in an easy and first view way, and don’t encounter some confusions or misunderstood with the results.

4.2.2. Independent Variables

Inequality in Education: To understand the impact of inequality in education on innovation, we utilize the variable of "Inequality in Education" from the Human Development Index. These variable measures the disparity in access to education and the quality of education among different population groups. The countries with the lowest score represent the least inequality in education. Inequality in education can negatively affect a society's capacity to innovate, as it limits equitable access to educational opportunities and hinders the development of skills and knowledge necessary for innovation.

Expenditure on education, % GDP: The ratio of government expenditure on education to GDP (current, capital, and transfer) is a valuable metric for comparing education spending across countries and assessing changes over time relative to the size of their economies. A larger percentage indicates a greater emphasis on education and the ability to generate revenue for public investments (WB, 2023).

Expected Years of Schooling (years): The school life expectancy represents the total duration, in years, that a child entering school can expect to spend in education from primary to tertiary levels. It is calculated by summing the age-specific enrollment rates across these levels (GII, 2023). Any portion of enrollment not accounted for by age is divided by the school-age population within the respective level and multiplied by the duration of that level. This value is then added to the sum of age-specific enrollment rates. A higher school life expectancy indicates a greater likelihood of children spending more years in education and a higher overall retention rate within the education system. However, it is important to note that the expected number of

years may not necessarily align with the number of completed education grades due to potential grade repetition.

Tertiary Education: The sub-pillar on tertiary education aims at capturing coverage (tertiary enrolment); priority is given to the sectors traditionally associated with innovation (with a series on the percentage of tertiary graduates in science, engineering, manufacturing, and construction); and the inbound and mobility of tertiary students, which plays a crucial role in the exchange of ideas and skills necessary for innovation

University/industry research collaboration: is the average answer to the survey question of the Executive Opinion Survey (EOS) from the World Economic Forum: In your country, to what extent do businesses and universities collaborate on research and development (R&D)? [1 = not at all; 7 = to a great extent]

QS university ranking average score top 3 universities: This indicator provides the average scores ranking of the universities that are in the top three of each country that belongs to the top 700 universities worldwide (WIPO, 2019). The QS University Ranking Average Score Top 3 Universities indicator provides information on the performance and potential for innovation at the top-ranked institutions in some factors such as faculty-student ratio, academic reputation, and research output, this means that a higher average score shows that these colleges are known for their innovation excellence and are anticipated to make substantial contributions to breakthroughs in a variety of sectors.

4.3. Model specification

For our research, we made use of a panel data model to investigate and analyze the impact of inequality in education on innovation. We examine how the variations in inequality in education influence the level of innovation across different entities over a four-year period, from 2018 to 2021, the panel data structure allows us to examine a sample made of the same set of entities across the four-year period, capturing both the within-entity variations across time and the between-entity differences at a given point in time. By utilizing this model, we can account for individual-specific and time-specific effects, enhancing the precision and dependability and accuracy of our findings (Andreß, 2017).

The objective of our research is focuses on understanding the relationship between inequality in education on innovation. Innovation serves as our dependent variable, on behalf of the level of innovative activities within each country. Acting as our primary independent variable of interest we have Inequality in education, that capture the disparities in educational opportunities and resources across the units. Also, to facilitate a comprehensive and in-depth analysis our model includes several control variables, such as government expenditure on education, expected years of education, tertiary education, university/industry research collaboration, and the average QS University ranking score for the top three universities. These control variables are selected based on their theoretical relevance and potential influence on innovation.

By including the control variables mentioned above, we aim to account for other factors that may influence innovation, such as the government's financial investment in education, educational attainment, collaboration that exist between academia and industry, and the reputation of higher education institutions of each country.Through

our panel data analysis, we aim to estimate the impact of inequality in education and other control variables on innovation. Findings will lean to light on how affects inequalities in education impacts innovative activities and provide insights into potential policy interventions or strategies to promote greater equity and foster a more innovative society.

To estimate the relationship between these variables, we employ three different regression models: Ordinary Least Squares (OLS), Random Effects, and Fixed Effects. These models allow us to account for individual-specific and time-specific effects, as well as unobserved heterogeneity. Each model provides us with unique advantages and addresses specific challenges, offering a comprehensive analysis of our research topic. Let's describe each model in-depth, highlighting its relevance to our research and the reasons for its inclusion

The ordinary Least Squares (OLS) model is an old and popular regression method. By minimizing the sum of squared residuals, it calculates the link between the dependent variable (innovation) and the independent variables (educational inequality and control variables). It also, provides straightforward coefficient estimates, demonstrating the magnitude and direction of the relationship between the dependent variable (innovation) and the independent variables (inequality in education and control variables). The amount and direction of the independent factors' effects on the dependent variable are indicated by estimations of the coefficients of the independent variables provided by the OLS model. It makes the assumption that the variables are linearly related and does not take into consideration unobserved personal or temporal influences.

However, OLS has some limitations when dealing with panel data or unobserved heterogeneity. Panel data often exhibit cross-sectional and time-series variations, and unobserved individual-specific or time-specific effects can bias the estimated relationships. To address these issues and account for unobserved heterogeneity, we have incorporated two advanced panel data regression techniques: the Random Effects model and the Fixed Effects model.

The Random Effects model is a panel data regression method that takes into account unobserved individual-specific effects that are presumed to be random in nature. The coefficients in this model represent the average impacts of the independent variables on the dependent variable across all dataset entities. The Random Effects model takes into account the effects of unobserved factors that may affect the relationship between educational inequality and innovation. It allows for heterogeneity among the entities. It is based on the supposition that the unobserved effects are unrelated to the explanatory factors.

Another panel data regression method that adjusts for unobserved time-invariant individual-specific effects is the Fixed Effects model. In order to account for entity heterogeneity that persists over time, it adds individual-specific intercepts to the regression equation. The Fixed Effects model successfully eliminates the impact of time-invariant personal traits, allowing to concentrate on within-entity variation. When unobserved factors could skew the estimated association between educational inequality and innovation, this approach is very helpful.

The robustness and validity of our findings are improved by incorporating these three models into our study. Each model, which takes into account various sources of

variation and unobserved heterogeneity, contributes to a thorough understanding of the connection between educational inequality and innovation. Drawing more precise and insightful conclusions from each model's results will help enlighten policymakers and researchers about the possible effects of eliminating educational inequality on promoting innovation and promoting economic growth.

The regression equation is expressed as follows

$$INNOVAT_{it}=\beta_0+\beta_1\times INEEDU_{it}+\beta_2\times EXPENEDU_{it}+\beta_3\times EXPSCHO_{it}+\beta_4\times TEREDU_{it}+\beta_5\times UNINDUSR_{it}+\beta_6\times QSRANK_{it}+\varepsilon_{it} \quad (1)$$

- INNOVATION it: The dependent variable representing innovation measured for each country (i) and over time (t).
- INEEDUit: The independent variable representing inequality in education measured for each country (i) and over time (t).
- EXPENEDUit: The independent variable representing expenditure on education measured for each country (i) and over time (t).
- EXPSCHOit: The independent variable representing expected years of schooling measured for each country (i) and over time (t).
- TEREDUit: The independent variable representing tertiary education measured for each country (i) and over time (t).
- UNINDUSRit: The independent variable representing university/industry research collaboration measured for each country (i) and over time (t).

- QSRANKit: The independent variable representing QS university ranking average score measured for each country (i) and over time (t).
- εit: The error term, representing the unexplained variation in innovation for each country (i) and over time (t).

By employing these regression models and utilizing panel data, we aim to provide a comprehensive analysis of the impact of inequality in education on innovation, while controlling for relevant factors. The inclusion of multiple models allows us to assess the robustness and consistency of our findings. Through this research, we seek to contribute to the understanding of the dynamics between educational disparities and innovative activities, providing insights for policy interventions and theoretical frameworks in this domain.

Chapter 5: Estimation Results

5.1. Descriptive Statistics and Correlation

Tables 1 and Table 2 list the descriptive statistics and Matrix of correlations. The mean value of the core explanatory variable Innovation in this research is only 69.617, indicating a relatively high average level of innovation. The standard deviation of 38.302 suggests considerable variability in innovation levels across the observations. However, there is a large gap between the maximum (126) and minimum (2) values of innovation

Table 6: Descriptive Statistics:

Descriptive Statistics				
Variable	**Mean**	**Std.Dev.**	**Minimum**	**Maximum**
Innovation	69.617	38.302	2.000	126.000
Expenditure in Education	54.870	37.109	0.000	118.000
Expected Years of Schooling	14.836	2.669	9.142	21.578
Inequality in education	15.138	13.522	1.256	50.124
Tertiary Education	62.047	35.758	2.000	121.000
University/industry research collaboration	61.023	37.211	0.000	124.000
QS university ranking average	50.464	26.835	3.000	78.000

Source: Author's elaboration with data from GII and HDI from 2018-2021

The variable Expenditure in Education has a mean of 54.870, indicating the average level of expenditure on education. The standard deviation of 37.109 suggests a significant dispersion in educational spending across the observations. The minimum (0.000) and maximum (118) values reflect the range of expenditure on education.

Expected Years of Schooling: represents the average number of expected years of education. The mean of 14.836 indicates the average expectation, while the standard

deviation of 2.669 shows a relatively small variation among the observations. The minimum (9.142) and maximum (21.578) values represent the lower and upper bounds of the expected years of education.

The variable Inequality in Education captures the level of inequality in education. The mean of 15.138 represents the average level of inequality, while the standard deviation of 13.522 indicates substantial variation across the observations. The minimum (1.256) and maximum (50.124) values reflect the range of inequality in education scores.

The variable Tertiary Education represents the extent of tertiary education provision. The mean of 62.047 suggests a relatively high average level of tertiary education. The standard deviation of 35.758 indicates considerable variation in the availability of tertiary education among the observations. The minimum (2.) and maximum (121.) values represent the lower and upper bounds of tertiary education provision.

The variable University/Industry research collaboration measures the extent of collaboration between universities and industries in research activities. The mean of 61.023 reflects the average level of collaboration, while the standard deviation of 37.211 suggests notable variation across the observations. The minimum (0.00) and maximum (124) values represent the lower and upper bounds of collaboration scores.

The variable QS university ranking Average has a mean of 50.464 indicates the average ranking, while the standard deviation of 26.835 shows variation in the rankings across the observations. The minimum (3.) and maximum (78) values reflect the range of university rankings.

Table 7: Correlation Matrix for Listed Variables

	Innovation	Expenditure in Education	Expected Years of Schooling	Inequality in education	Tertiary Education	University/industry research collaboration	QS university ranking average
Innovation	1.000	-0.381	0.778	-0.793	-0.784	-0.637	-0.721
Expenditure in Education	-0.381	1.000	-0.387	0.298	0.236	0.211	0.274
Expected Years of Schooling	0.778	-0.387	1.000	-0.753	-0.735	-0.460	-0.628
Inequality in education	-0.793	0.298	-0.753	1.000	0.692	0.387	0.437
Tertiary Education	-0.784	0.236	-0.735	0.692	1.000	0.433	0.590
University/industry research collaboration	-0.637	0.211	-0.460	0.387	0.433	1.000	0.643
QS university ranking average	-0.721	0.274	-0.628	0.437	0.590	0.643	1.000

Source: Author's elaboration with data from GII and HDI from 2018-2021

Expenditure on education exbibits a negative correlation with innovation (r = -0.381). This suggests that higher levels of expenditure on education tend to be associated with lower levels of innovation. In the other hand there is a positive correlation between Expected Years of Education and innovation (r = 0.778). This indicates that regions with higher expectations for years of education tend to have higher levels of innovation.

Inequality in education shows a strong negative correlation with innovation (r = -0.793). This implies that higher levels of inequality in education are associated with lower levels of innovation. Moreover, the variable Tertiary education" exhibits a negative correlation with innovation (r = -0.784). This suggests that regions with higher levels of tertiary education provision tend to have lower levels of innovation.

University/industry research collaboration shows a negative correlation with innovation (r = -0.637). This indicates that stronger collaboration between universities and industries in research activities is associated with lower levels of innovation.

There is a negative correlation between Qs university ranking and innovation (r = -0.721). This suggests that higher university rankings, particularly the average score of the top 3 universities, tend to be associated with lower levels of innovation.

5.2. Regression Results

Table 8: Regression Results

	OLS Model	Fixed Effect	Random Effect
Inequality In Education	-1.113 (-9.023*)	-0.084 (-0.253)	-1.076 (-6.438*)
Expenditure In Education	-0.091 (-2.983*)	0.044 (2.439*)	0.046 (2.718*)
Expected years of Schooling	0.348 (0.480)	0.885 (0.569)	3.072 (3.392*)
Tertiary Education	-0.262 (-5.489*)	0.025 (0.533)	-0.035 (-0.847)
University/Industry Research Collaboration	-0.201 (-5.350*)	0.033 (0.943)	-0.005 (-0.148)
QS University ranking average	-0.346 (-5.639*)	-0.172 (-1.077)	-0.515 (-6.349*)
Constant	132.980 (9.373)		66.973 (3.960)
Rsquared	0.857	0.996	
Adjusted R-squared	0.852	0.994	

Source: Author's elaboration with data from GII and HDI from 2018-2021

Note: * indicates statistical significance at the 95% confidence level.

Note: T-ratio is included in the parenthesis

The results show significant findings concerning the impact of various factors on innovation.

First, inequality in education consistently showed a significant and negative impact with innovation across (OLS: t = -9.023, Random Effects: t = -6.438, but not at the Fixed Effects: t = -0.253. This indicates that a higher level of inequality in education is associated with lower levels of innovation.

Inequality in Education: In two models (Random and OLS), has a higher level of inequality in education is associated with lower levels of innovation. The coefficient estimates indicate that an increase of 1 unit in inequality in education is associated with a decrease ranging from 0.084 to 1.113 units in innovation. These relationships are statistically significant across the two models mentioned before.

Secondly, Government Expenditure on Education showed a significant negative impact on innovation in the OLS model (t = -2.983), indicating that an increase in government spending on education is associated with a decline in innovation, in other words we can say: an increase in government expenditure on education by 1 unit is associated with a decrease of approximately 0.091 units in innovation. The T-ratio suggests that this relationship is statistically significant because t- ratios are 2.718 and 2.439, this represents a positive impact for Random and Fixed Effects models.

On the other hand, expected years of Education is not significant in the OLS model (t = 0.480), suggesting that an increase in expected years of education leads to higher levels of innovation, or that an increase of 1 unit in expected years of education is associated with an increase of approximately 0.348 units in innovation, and this relationship is not statistically significant. However, this relationship is significant in the Random Effects (t=2.718) and Fixed Effects models (t= 2.439).

The impact of Tertiary Education and university/industry research collaboration (UNINDUSR) on innovation was inconclusive. While the OLS model suggested a significant negative relationship between tertiary education and innovation (t = -5.489, the Random Effects and Fixed Effects models did not yield statistically significant results. Similarly, the impact of university/industry research collaboration on innovation was significant in the OLS model (t = -5.350) but not in the other models.

In the variable Tertiary Education: the coefficient estimates for tertiary education vary across the models. In the OLS model, an increase in tertiary education by 1 unit is associated with a decrease of approximately 0.262 units in innovation, and this relationship is statistically significant. However, in the Random Effects and Fixed Effects models, the estimated coefficients are close to zero and statistically insignificant.

The coefficient estimates for the variable University/industry research collaboration also differ across the models. In the OLS model, an increase in university/industry research collaboration by 1 unit is associated with a decrease of approximately 0.201 units in innovation, and this relationship is statistically significant. In the Random Effects and Fixed Effects models, the estimated coefficients are close to zero and statistically insignificant.

Lastly, the QS university ranking average score for the top 3 universities displayed a significant relationship with innovation across two model (OLS: t = -5.639, Random Effects: t = -6.349. This suggests that a higher ranking of universities in the QS ranking

is significantly associated with lower levels of innovation, but is not significant in the Fixed Effects: t = -1.077.

QS university ranking average score for the top 3 universities: The coefficient estimates for this variable show a negative relationship with innovation in all three models. However, the magnitudes of the coefficients vary. In the OLS model, an increase of 1 unit in the QS university ranking score is associated with a decrease of approximately 0.346 units in innovation, and this relationship is statistically significant. In the Random Effects and Fixed Effects models, the estimated coefficients are larger and also statistically significant.

Chapter 6: Conclusion

The outcomes of this study shed light on the intricate relationship between education inequality and innovation and help us to answer and understand the impact of inequality in education on innovation. The results consistently demonstrate that higher levels of inequality in education have a significant and negative impact on innovation, and aligns with prior research highlighting the vital role of equitable education systems in cultivating innovation. This negative association is robust across the Ordinary Least Squares (OLS) and Random Effects models, as we described before with a t-ratio of -9.023 and -6.438. However, it's noteworthy that the Fixed Effects model did not yield a statistically significant result, suggesting potential contextual nuances that warrant further investigation.

The findings also imply that spending on research and development in the education industry is a major driver of innovation. Additionally, as education inequality has a detrimental effect on a nation's capacity for innovation, lowering education inequality is essential to creating an atmosphere that supports innovation. These conclusions may apply to other nations or regions facing comparable problems with educational inequality and innovation in addition to the study's particular setting. Also, highlighting the role of education in promoting innovation and economic development and with the demands for policies and program that enable equal educational opportunities and strengthen society’s innovative capacity, and emphasizing the investment in education and research and development in the education sector as a key strategy to promote the innovation in a country.

Policymakers and educators should take into account the effects of the cited factors on creativity from a practical standpoint. Innovation may be boosted by raising government spending on education and boosting postsecondary education. A more inventive atmosphere can also result from encouraging university-industry research collaboration and raising university rankings. These results highlight the requirement for focused actions and regulations meant to lessen educational inequality and promote innovation.

It is critical to recognize this study's constraints. The research may not reflect long-term trends or changes in the link between disparity in education and innovation because it is based on panel data from a limited time period of four years (2018-2021). The outcomes could potentially be influenced by other unseen factors. Additionally, because the study concentrates on a particular set of control variables, it is possible that other variables that influence innovation but were left out of the analysis also exist.

Several recommendations for further study and policy implications can be made in light of the findings. To further understand how educational inequality influences innovation, more research is required. Longitudinal investigations can give a more thorough grasp of the dynamics and causal connections at play. The study might also look into the precise ways that government spending on education, tertiary education, university-industry research partnerships, and university rankings affect innovation.

By guaranteeing equal access to high-quality education, policies should be taken to eliminate educational disparity, particularly in underprivileged populations. Knowledge transfer and innovation should be facilitated by policies that support

collaboration between institutions and industries. Governments might also concentrate on promoting programs that advance tertiary education and raise the standard of educational systems as a whole.

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