

Thesis for the Degree of Master

**Impact of the Digital Competitiveness on
the Labor Market during the Fourth
Industrial Revolution, 2017-2021**

**디지털 경쟁력이 4차 산업혁명 시대
노동시장에 미치는 영향, 2017-2021**

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A thesis supervisor: Hwang GeeHyun

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requirements for the Degree of Master**

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**Graduate School of Information Sciences
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ABSTRACT

Impact of the Digital Competitiveness on the Labor Market during the Fourth Industrial Revolution, 2017-2021

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This exploratory study aimed to evaluate the impact of digital competitiveness on labor market indicators (labor productivity, informal employment, employee earnings and unemployment) during the Fourth Industrial Revolution from 2017 to 2021. Secondary data from IMD WDC and ILOSDG were analyzed using SmartPLS 4.0, employing PLS-SEM with 115 cases and 5000 bootstraps at a significance level of 0.05. The results indicate that only formative and single-item constructs were used, VIF and individual reliability were accepted. Satisfactory R2 and Q2 values were obtained for informal employment (.455, .444), employee earnings (.506, .488) and unemployment (.214, .194), but not for labor productivity. Additionally, a relationship was found between Digital Competitiveness and the indicators: informal employment ($\beta=-.675$, $t=14.181$, $p<.001$), employee earnings ($\beta=.712$; $t=16.678$, $p<.001$), and unemployment ($\beta=-.462$, $t=6.212$, $p<.001$); while no relationship

was observed with labor productivity ($\beta=-.015$, $t=0.185$, $p=0.853$). Therefore, it can be concluded that Digital Competitiveness did not significantly affect labor productivity but had a significant impact on reducing informal employment, increasing employee earnings and lowering unemployment rates.

Keywords: Digital competitiveness, labor productivity, informal employment, employee earnings, unemployment, PLS-SEM

국문초록

디지털 경쟁력이 4차 산업혁명 시대 노동시장에 미치는 영향, 2017-2021

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본 탐색적 연구는 2017년부터 2021년까지 4차 산업혁명 기간 동안 디지털 경쟁력이 노동시장 지표(노동생산성, 비공식 고용, 근로소득, 실업률)에 미치는 영향을 평가하는 것을 목적으로 했습니다. SmartPLS를 이용하여 IMD WDC와 ILOSDG의 2차 자료를 분석하였습니다. PLS 4.0은 115건의 사례와 0.05의 유의 수준에서 5000개의 부트스트랩이 있는 PLS-SEM을 사용합니다. 결과는 조형적 및 단일 항목 구성만 사용되었으며 VIF 및 개별 신뢰성이 수용되었음을 나타냅니다. 비공식 고용(.455, .444), 직원 소득(.506, .488) 및 실업(.214, .194)에서는 만족스러운 R2 및 Q2 값이

얻어졌지만 노동 생산성에서는 그렇지 않았습니다. 또한 디지털 경쟁력과 지표 사이에는 비공식 고용($\beta=-.675$, $t=14.181$, $p<.001$), 직원 소득($\beta=.712$; $t=16.678$, $p<.001$), 실업($\beta=.462$, $t=6.165$, $p<.001$)의 관계가 발견되었지만 노동 생산성($\beta=0.015$, $t=0.0.3$)은 관찰되지 않았습니다. 따라서 디지털 경쟁력은 노동생산성에 유의한 영향을 미치지 않는 않지만 비공식 고용 감소, 근로자 소득 증가, 실업률 감소에 유의한 영향을 미쳤다는 결론을 내릴 수 있습니다.

키워드: 디지털 경쟁력, 노동 생산성, 비공식 고용, 직원 소득, 실업,

PLS-SEM

CHAPTER 1: INTRODUCTION

The Fourth Industrial Revolution has brought about significant changes in the way societies function, and one of the most important aspects of this transformation is the adoption of digital technologies that can bring changes in the labor market. Therefore, this thesis aims to explore the impact of digital competitiveness on the labor market from 2017 to 2021. The labor market indicators are: labor productivity, informal employment, employee earnings, and unemployment.

Chapter 1 outlines the problem statement, research questions, objectives, and justification for the study. Chapter 2 provides a literature review and theoretical framework, including definitions of key terms. Chapter 3 explains the research methodology, including research model, hypotheses, variables operationalization, population and sample, and data collection and analysis techniques. The analysis and results are presented in chapter 4, followed by a discussion of the results. Finally, the conclusions and recommendations are presented in chapter 5.

Overall, this thesis provides valuable insights into the impact of digital competitiveness on the labor market during the Fourth Industrial Revolution, and it may be useful for policymakers, business leaders, and academics.

1.1 PROBLEM STATEMENT

The Fourth Industrial Revolution is characterized by the continuous development and accelerated global expansion of new technologies. This generates a process of change called digital transformation, which in turn leads to changes in the labor market. (PUCP, 2019)

A study published by the World Economic Forum (2020b) predicts that by 2025, cloud computing, big data, and e-commerce will be of high priority, and a significant number of companies will adopt non-humanoid robots and artificial intelligence for production processes. These technologies are expected to become the foundation of work in all modern industries in the long run. (Novella & Rosas-Shady, 2022)

In this prediction, employers expect that, only 9% of the workforce will have replaceable roles, and emerging professions (related to new technologies) will increase to 13.5%. Based on these figures, 85 million jobs may be displaced due to a shift in the division of labor between humans and machines, while 97 million new jobs may emerge to meet the new technological demands of companies. (Novella & Rosas-Shady, 2022)

On the other hand, according to the analysis conducted by the Organization for Economic Cooperation and Development (OECD), approximately 25% of jobs in

Latin America and the Caribbean face a significant risk of being automated. Estimates for Chile, Ecuador, Mexico, and Peru, Chile has the lowest estimate with 21%, while the highest estimate is in Peru with 28%. Furthermore, there is a possibility that 35% of jobs in these countries may experience considerable changes in their tasks and work processes. In contrast, the OECD predicts that only 14% of jobs in its member countries are likely to be replaced by automation. (OECD et al., 2020)

According to the Digital Economy and Society Index report by the European Commission (2021), only 31% of people in the European Union have digital skills above basic, while 56% have basic skills. These low rates of digital knowledge are reflected in the difficulties that companies face in filling vacancies related to the use of technology; in 2019, more than half (55%) of EU companies reported difficulties in finding such vacancies. (Novella & Rosas-Shady, 2022)

As explained, the adoption of new digital technologies is causing changes in the labor market. However, it is unclear whether these changes will occur in the same way in all countries. This uncertainty leads to the research question.

1.1.1 GENERAL RESEARCH QUESTION

How does digital competitiveness affect the labor market indicators during the Fourth Industrial Revolution from 2017 to 2021?

1.1.2 SPECIFIC RESEARCH QUESTION

- How does digital competitiveness affect labor productivity during the Fourth Industrial Revolution from 2017 to 2021?
- How does digital competitiveness affect informal employment during the Fourth Industrial Revolution from 2017 to 2021?
- How does digital competitiveness affect employee earnings during the Fourth Industrial Revolution from 2017 to 2021?
- How does digital competitiveness affect unemployment during the Fourth Industrial Revolution from 2017 to 2021?

1.2 RESEARCH OBJECTIVES

1.2.1 GENERAL OBJECTIVE

To evaluate the impact of the digital competitiveness on labor market indicators during the Fourth Industrial Revolution from 2017 to 2021.

1.2.2 SPECIFIC OBJECTIVES

- To measure the impact of the digital competitiveness on labor productivity during the Fourth Industrial Revolution from 2017 to 2021.
- To assess the impact of the digital competitiveness on informal employment during the Fourth Industrial Revolution from 2017 to 2021.
- To evaluate the impact of the digital competitiveness on employee

earnings during the Fourth Industrial Revolution from 2017 to 2021.

- To appraise the impact of the digital competitiveness on unemployment during the Fourth Industrial Revolution from 2017 to 2021.

1.3 RESEARCH JUSTIFICATION

Industrial revolutions have happened as a consequence of the search for better living conditions. Although there has always been the fear that innovations will reduce the number of workers, this has not occurred significantly. The facts have shown changes in working conditions with the aim of optimizing processes and making them more efficient and effective, generating an improvement in living conditions. Three industrial revolutions have already occurred and we are currently in the process of the fourth revolution, where basically it is looking for the digital transformation of societies, governments, and companies. Therefore, this research is justified for the following reasons:

First, Fourth Industrial Revolution through digital transformation has the potential to support economic growth around the world by generating higher output at lower costs, increasing aggregate demand, and influence in the labor market. Policymakers must understand the direction of technology, if it replaces workers, they must address the rising unemployment and inequality, if it mainly displaces workers, they need to focus on developing specialized skills in the workforce.

Secondly, since a significant number of companies and associations are adopting advanced digital technologies to improve their business plan, the workforce is required to possess digital skills and the necessary expertise to understand new technologies. For that reason, according to many authors, digital technology will have an impact on the labor market.

Third, similar studies have been carried out in developed countries or by continent, but the impacts have been different from one country to another. However, there is still a need to investigate whether the impact of digital transformation affects the labor market taking countries from different parts of the world as a sample, specifically Peru. To analyze the digital transformation during Fourth Industrial Revolution, the World Digital Competitiveness ranking is used to show which countries adopt and utilize digital technologies leading to transformation.

For all of the above, the present research is supported to provide valuable insights for governments and businesses to identify areas of the workforce that require more attention and to develop effective strategies when initiating digital transformation.

CHAPTER 2: LITERATURE REVIEW

2.1 RESEARCH BACKGROUND

Abbasabadi H. and Soleimani M. (2021) in Iran analyzed the research article “Examining the effects of digital technology expansion on Unemployment: A cross-sectional investigation”. The study examined the relationship between three technology indexes (ICT Development Index, The Digital Index, and Technological Readiness) on the unemployment. The information was analyzed using empirical research techniques such as Ordinary Least Squares (OLS) and Generalized Least Squares (GLS) estimation methods, as well as stability tests. The study sample consisted of 163 countries from the year 2016.

According to their findings, there is a significant second-degree polynomial relationship between unemployment and technology indexes. Based on the empirical methodology, the relationship has a positive coefficient in the first degree and a negative coefficient in the second degree. This suggests that as digital technology indexes increase, unemployment initially rises until it reaches a peak value, and then it begins to decline as digital technology expansion surpasses a specific value. (Abbasabadi & Soleimani, 2021)

Basol O. and Yalcin E. (2021) in Turkey studied “How does the digital economy and society index (DESI) affect labor market indicators in EU countries?”. To determine the effects of the DESI (connectivity, human capital/digital skills, use of internet service by citizens, integration of digital technology and digital public services) on labor market indicators (labor market insecurity, long-term unemployment rate, employment rate, and personal earnings). The research analyzed 2018 DESI data on the Better Life Index (job) from 23 countries of the European Union. This data was executed with SmartPLS 3.0 program with 23 cases and 5000 bootstraps.

Their results showed that an increase in DESI data has increased positive labor market indicators such as the employment rate and personal income (t: 15.929, 0.849); on the contrary, it has decreased the negative labor market indicators like long-term unemployment rate and labor market insecurity (t: 3,685; -0,535). Therefore, the digitalization in EU countries in 2018 had a positive impact on labor market indicators. (Basol & Yalcin, 2021)

Boorish J. et al. (2022) conducted research in Saudi Arabia entitled “The labor market in the digital era: What matters for the Gulf Cooperation Council countries?”. The objective of the research was to explore the effect of digitalization on employment in Gulf Cooperation Council (GCC) countries and compare them to some selected advanced countries. To develop the research, the analysis was carried out using second-generation unit root tests and the Auto Regressive Distributed Lag

(ADRL) model for the period 2000-2020.

In their research, the result was that the use of ICT shows a negative and significant impact on employment in both industrial and services sectors in GCC countries. The reason for this outcome could be attributed to the deficiency of qualified labor in GCC countries. In contrast, developed countries show a positive and significant effect of ICT on total employment, particularly in the industrial sector. Developed countries have the adjustment rate significantly higher than GCC countries. (Bousrih, Elhaj, & Hassan, 2022)

Ivanitskaia V. (2022) in Hungary investigated “The impact of digitalization on unemployment: the case of the Nordic countries”. The variables Individuals using the Internet (digitalization) and the unemployment rate were evaluated for five Nordic countries such as Iceland, Finland, Norway, Denmark, and Sweden, for the period 1991-2019. The research was conducted using robust Ordinary least squares (OLS) regression in STATA.

Her results indicate that, on average, there was a high significance and a negative association between digitalization and unemployment. Specifically, a 1% increase in digitalization led to a 0.025% decrease in unemployment in the Nordic countries. (Ivanitskaia, 2022)

2.2 THEORETICAL FRAMEWORK

2.2.1 FOURTH INDUSTRIAL REVOLUTION

The term "Fourth Industrial Revolution," coined by Klaus Schwab, founder of the World Economic Forum, during the edition of the World Economic Forum in 2016, refers to a phase marked by a range of emerging technologies that are fusing the physical, digital and biological. Technologies such as robotics, artificial intelligence, blockchain, nanotechnology, quantum computing, biotechnology, the Internet of Things, 3D printing, autonomous vehicles, so on. (Schwab, 2017)

The progression of industrial revolutions, since the mechanization in the First to the mass production in the Second and the automation in the Third, has significantly elevated global standards of living. However, the potential impact of advancements in technology arising from the fourth industrial revolution is deemed even more transformative than the cumulative effects of the preceding three revolutions. (Xu, David, & Kim, 2018)

The Fourth Industrial Revolution poses a range of challenges, from income inequality, cybersecurity and ethical dilemmas. One of these challenges is job displacement and the need for a workforce with new and evolving skill sets. Adapting to these changes requires a proactive approach from individuals,

businesses, and policymakers to ensure a sustainable and inclusive future. For Schwab, technology empowers people rather than replaces them; progress serves society rather than disrupts it. (Schwab, 2017)

Overcoming these obstacles is crucial to harness the benefits of this Revolution, which will reshape societies, institutions, and economies globally, transforming the ways we live, work, and interact with one another. Understanding these new technologies and their disruption potential is critical for all countries, particularly for developing countries. (Xu, David, & Kim, 2018)

2.2.2 DIGITAL COMPETITIVENESS

The Fourth Industrial Revolution is impacting businesses and countries, with rapid technological advancements like 3D-printing, robotics and digital currencies, as mentioned before. These changes are transforming economies and introducing new opportunities and challenges that will shape future performance. (IMD, 2017)

Governments globally are investing in scientific and technological infrastructure to remain competitive in the digital economy and improve the well-being of their citizens. (IMD, 2017)

Therefore, Digital competitiveness is defined as “The capacity of an economy to

adopt and explore digital technologies leading to the transformation in government practices, business models and society in general” (IMD, 2017).

The World Competitiveness Center of the Institute for Management Development (IMD) recognized the need for a new framework to assess digital competitiveness, leading to the creation of the IMD World Digital Competitiveness (WDC) Ranking. (IMD, 2017)

Arturo Bris, Director of the WCC, explains that the ranking highlights how national factors play a crucial role in explaining the digital transformation of businesses and the adoption of digital practices by citizens. He adds that digital countries are formed through a blend of factors such as digital talent, digital regulations, data governance, digital attitudes, and the availability of capital. (IMD, 2017)

The IMD World Digital Competitiveness ranking assesses and ranks the degree to which countries embrace digital technologies, leading to changes in government practices, business models, and society as a whole. For that reason, this ranking focuses on evaluating the capabilities and preparedness of economies for digital transformation. (IMD, 2017)

The digital competitiveness ranking complements the overall ranking by providing insight on the role of the digital economy in a country's performance. (IMD, 2017)

Digital transformation takes place at the enterprise (private or state-owned), government, and societal levels. Also, it requires changes at the organizational, institutional, and structural levels. Organizations must be able to adapt to new technologies, institutions need to be open and flexible, and the structure should encourage innovation. (IMD, 2017)

Based on its methodology, The WDC Ranking considers the digital competitiveness through three main factors: knowledge, technology, and future readiness. (IMD, 2017)

Each of these factors is divided into three sub-factors. These nine sub-factors consist of 54 criteria, and even though each sub-factor does not necessarily have the same number of criteria, each sub-factor has an equal weight of approximately 11.1% ($100 \div 9 \sim 11.1$) in the overall results. (IMD, 2017)

Of the 54 criteria used in the WDC ranking, 19 are new indicators that are only used in this ranking, while the others are shared with the IMD World Competitiveness Ranking. Additionally, three criteria (Exchange rate, population and gross domestic product (GDP)) are used only for background information and do not affect the overall competitiveness ranking. (IMD, 2017)

Criteria are categorized as either hard data or soft data (S) (34 hard and 20 survey

data). Hard data criteria measure digital competitiveness quantitatively, such as internet bandwidth speed, while soft data criteria assess competitiveness qualitatively, such as the agility of companies. Hard data criteria have a weight of 2/3 in the overall ranking, while soft data criteria have a weight of 1/3. (IMD, 2017)

2.2.2.1 KNOWLEDGE

In the context of digital competitiveness, Knowledge refers to the expertise needed to develop and utilize new technologies, as well as the underlying infrastructure required for the process of digital transformation, which involves discovering, understanding, and learning about new technologies. These are the sub-factors under the Knowledge factor: (IMD, 2017)

I. Talent

1. Educational assessment PISA – Math: PISA survey of 15-year-olds.
2. (S) International experience: International experience of senior managers is generally significant.
3. (S) Foreign highly-skilled personnel: Foreign highly-skilled personnel are attracted to your country's business environment.
4. (S) Management of cities: Management of cities supports business development.
5. (S) Digital/Technological skills: Digital/Technological skills are

readily available.

6. Net flow of international students: Tertiary-level international students inbound minus students outbound (per 1000 people).

II. Training and Education

7. (S) Employee training: Employee training is a high priority in companies.
8. Total public expenditure on education: Percentage of GDP.
9. Higher education achievement: Percentage of population that has attained at least tertiary education for persons 25-34.
10. Pupil-teacher ratio (tertiary education): Number of pupils per teacher.
11. Graduates in Sciences: Percentage of graduates in ICT, Engineering, Math & Natural Sciences.
12. Women with degrees: Share of women who have a degree in the population 25-65.

III. Scientific Concentration

13. Total expenditure on research and development (%): Percentage of GDP.
14. Total research and development personnel per capita: Full-time work equivalent (FTE) per 1000 people.
15. Female researchers: Percentage of total (headcount FT&PT).

16. Research and development productivity by publication: Number of scientific articles over R&D expenditure (as % GDP).
17. Scientific and technical employment: Percentage of total employment.
18. High-tech patent grants: Percentage of all patents granted by applicant's origin (average 2017-2019).
19. Robots in education and research and development: Number of robots.

2.2.2.2 TECHNOLOGY

Technology evaluates the broader context in which the digital technologies are developed, including the regulatory environment that facilitates business activities, ensures compliance with regulations, and promotes innovation. Sub-factors under Technology are: (IMD, 2017)

I. Regulatory Framework

20. Starting a business: Distance to Frontier.
21. Enforcing contracts: Distance to Frontier.
22. (S) Immigration laws: Immigration laws do not prevent your company from employing foreign labor.
23. (S) Development & application of technology: Development and application of technology are supported by the legal environment.
24. (S) Scientific research legislation: Laws relating to scientific research

do encourage innovation.

25. (S) Intellectual property rights: Intellectual property rights are adequately enforced.

II. Capital

26. information technology and media stock market capitalization: Percentage of total stock market capitalization.
27. (S) Funding for technological development; Funding for technological development is readily available.
28. (S) Banking and financial services: Banking and financial services do support business activities efficiently.
29. Country credit rating: Index (0-60) of three country credit ratings: Fitch, Moody's and S&P.
30. (S) Venture capital: Venture capital is easily available for business.
31. Investment in Telecommunications: Percentage of GDP

III. Technological Framework

32. (S) Communications technology: Communications technology (voice and data) meets business requirements.
33. Mobile Broadband subscribers: 4G and 5G market, percentage of mobile market.
34. Wireless broadband: Penetration rate (per 100 people).

35. Internet users: Number of internet users per 1000 people.
36. Internet bandwidth speed: Average speed.
37. High-tech exports (%): Percentage of GDP.

2.2.2.3 FUTURE READINESS

Future readiness is about assessing a country's preparedness for digital transformation, including the adaptive attitudes needed to absorb available digital technologies like internet purchases. Readiness also calls for business flexibility and the ability to transform models to leverage new opportunities, as well as private sector innovation. Evaluating practices and processes related to IT is also an essential component of readiness. The sub-factors for Future readiness are: (IMD, 2017)

I. Adaptive Attitudes

38. E-Participation: Use of online services that facilitate public's interaction with government.
39. Internet retailing: US\$ Per '000 People.
40. Tablet possession: Percentage of households.
41. Smartphone possession: Percentage of households.
42. (S) Attitudes toward globalization: Attitudes toward globalization are generally positive in your society.

II. Business Agility

43. (S) Opportunities and threats: Companies are very good at responding quickly to opportunities and threats.
44. World robots' distribution: Percentage share of world robots.
45. (S) Agility of companies: Companies are agile.
46. (S) Use of big data and analytics: Companies are very good at using big data and analytics to support decision-making.
47. (S) Knowledge transfer: Knowledge transfer is highly developed between companies and universities.
48. Entrepreneurial fear of failure: Percentage indicating that fear of failure would prevent them from setting up a business.

III. IT Integration

49. E-Government: Provision of online government services to promote access and inclusion of citizens.
50. (S) Public-private partnerships: Public and private sector ventures are supporting technological development.
51. (S) Cyber security: Cyber security is being adequately addressed by corporations.
52. Software piracy: Percentage of unlicensed software installation.
53. Government cyber security capacity: The government's capability to mitigate harm from cyber security threats.

54. Privacy protection by law content: Extent of the legal framework to protect Internet users' privacy.

2.2.3 LABOR MARKET

As part of the discussion about the future of work, some authors argue that the ongoing transformation is unique this time due to the peculiar nature and scope of the digital revolution and its far-reaching implications. Key technological areas, such as the Internet of Things, cloud computing, 3D printing, cybersecurity, big data and analytics, new telecommunications networks, AI and collaborative robotics, augmented reality, virtualization, and simulation, are essential for the digital transformation and in the way businesses and industries operate and develop during the Fourth Industrial Revolution. (CCOO industria, 2017)

In this context, it is important to differentiate the terms "Digitization", "Digitalization", and "Digital Transformation", often used interchangeably but have distinct meanings. Digitization is the conversion of analogue material to digital format; Digitalization involves adopting or increasing the use of digital technology; and Digital Transformation requires cross-cutting organizational change and implementation of digital technologies. Digitalization and Digital Transformation are the most significant terms when discussing the impact of digital technology on society, but the effects on the Labor market are not very clear. (Larsson & Teigland,

2020)

Historically, most people worked in the primary sector, but during the First Industrial Revolution, there was a shift towards the secondary sector of manufacturing. However, since World War II, there has been a trend towards the tertiary sector of services, which now employs around 70% of workers. Some authors mention the emergence of a fourth and fifth sector, which involve high-level intellectual services and information services. (Wisskirchen, 2017)

New work conditions demand new skills, specifically digital ones. Digital skills refer to the ability to effectively and creatively use digital devices, applications, and communication networks to find and manage information, create and share digital content, collaborate and interact, and solve problems. (Goloventchik, 2018)

The level of technological development and skills among young people is crucial for each country's future labor market. Young people in developing nations are optimistic about their professional prospects, with more confidence than those in developed countries. However, in many developing countries, only those with significant IT knowledge are willing to improve their technological skills. (Wisskirchen, 2017)

The issue with automation is not the number of jobs that may be lost, but rather

whether there will be enough new jobs created to compensate for the job losses caused by digitalization, as occurred in previous industrial revolutions. Research literature and expert opinions vary on this topic, with some predicting irreversible changes in society and others expecting a gradual but rapid adaptation to these changes. (CCOO industria, 2017)

Broadly speaking, the concept of digitalization refers to the extensive use of digital technology through connected services and devices. It is widely agreed upon that digitalization has the potential to transform the production, distribution, and consumption of goods and services, as well as the required jobs and business models. As a result, this will have an impact on economic growth, the types of industries and production methods, leading to changes in employment levels, salaries, job quality, skills, working conditions and social welfare, among other areas. (CCOO industria, 2017)

For G. Goloventchik, automation of work is likely to cause income stratification, increased unemployment, and reduced income and living standards for those in areas with limited job opportunities. Researchers predict that it will lead to a societal division between highly skilled professionals and low-skilled workers.

In 2015, the United Nations General Assembly adopted the 2030 Agenda and the Sustainable Development Goals (SDGs), which are a set of 17 goals aimed at ending

poverty, protecting the planet, and ensuring peace and prosperity for all. The SDGs cover a wide range of social and economic development issues, including poverty, hunger, health, education, climate change, gender equality, water, sanitation, energy, the environment, and social justice. The International Labor Organization (ILO) contributes by providing high-quality data on 14 SDG indicators, grouped under 5 goals, to measure and monitor progress towards the SDGs, which are presented in the ILOSDG database. (ILO, 2023)

As mentioned, this research takes the following general indicators from the SDG Labor Market:

1. Indicator 8.2.1: Annual growth rate of real GDP per employed person.
2. Indicator 8.3.1: Proportion of informal employment in total employment.
3. Indicator 8.5.1: Average hourly earnings of employees (due to the lack of data, the data Average monthly earnings of employees is used)
4. Indicator 8.5.2: Unemployment rate.

2.2.3.1 LABOR PRODUCTIVITY

Labor productivity is a crucial measure of efficiency for companies. Digital transformation is an important factor that can significantly impact labor productivity. By implementing information and communication technologies (ICT), enterprises can restructure their economic sectors and achieve higher

levels of productivity. These technologies improve business processes, reduce transaction costs, and enhance resource utilization. (Varlamova & Larionova, 2020)

In EU countries, it was found that ICT components have a positive impact on labor productivity, but in transition economies, the impact of ERP, e-commerce and CRM programs is even greater. Multiple studies have explored the factors that affect labor productivity, showing a negative correlation with employment rates and positive associations with human and fixed capital, oil income, financial development, trade openness, and innovation. (Varlamova & Larionova, 2020)

Vietnam aims to become a high-income country by 2045 but faces challenges due to its current average GDP growth rate. To achieve high GDP growth, the focus should shift to increasing labor productivity through accelerating the digital transformation. According to the Data 61 Foundation from 2020-2030, the digital economy is expected to contribute to labor productivity growth from 7% to 16.5% annually (VietNamnet, 2022). The World Economic Forum has recognized the ICT sector as a significant contributor to output growth. It predicts that the sector's influence on GDP growth will range from 1.4% in emerging markets to 2.5% in China. (Aly, 2020)

The implications of digital transformation vary across countries. In developed economies, digitalization enhances productivity and growth but can impact job availability as lower-skill work is often outsourced to emerging markets. Conversely, emerging markets benefit more from digitization's impact on employment and exports, rather than its influence on growth. (Aly, 2020)

O. Romanova and A. Ponomareva shows that the high rates of digital transformation of industry in modern conditions can solve such fundamental problems as increasing labor productivity and improving the population's well-being. (Romanova & Ponomareva, 2022)

On the other hand, the replacement of human jobs with robots or artificial intelligence poses several problems. Firstly, a well-paid worker loses their job or is moved to a less well-paid job, which reduces their income and consumption, thus not contributing to production growth. (Goloventchik, 2018)

Secondly, various types of taxes, including municipal taxes, are reduced or stopped altogether, which becomes a problem not only for the employee but also for the local community where robotic production takes place. The robot does not pay income tax or contribute to pension funds. (Goloventchik, 2018)

Thirdly, the total or partial release of an employee, due to a reduction in working

hours by the use of technology, generates more leisure time and a lack of knowledge of how to use it. (Goloventchik, 2018)

B. Gates believes that in the future, the tax system should change, and special tariffs for robots should be introduced to slow down the automation process and allow people to keep their jobs. There cannot be direct prohibitions; however, an employer who replaces ten human jobs with one robotic one should be aware that their actions will have consequences in the form of additional taxes on the robot to compensate for the employment losses. (Goloventchik, 2018)

The possibility of introducing a tax on robotic jobs was considered in a meeting of the European Commission in 2017. The revenues from this tax were supposed to be used for the professional retraining of workers who lose their jobs due to automation. However, the idea was rejected for fear that such a tax would have a very negative impact on the high-tech market and the competitiveness. (Goloventchik, 2018)

The current study focuses on SDG indicator 8.2.1, which measures the Annual growth rate of real GDP per employed person (constant 2017 international dollars at Purchasing Power Parity-PPP). This indicator is derived from the ILO modelled estimates and has been adjusted to accommodate variations in national data, scope of coverage, data collection, tabulation methodologies, and other

country-specific factors. (ILO, 2023)

GDP represents the monetary value of goods and services purchased by the final user in an economic territory/country during a period. As a result, Real GDP is an adjusted measure that takes into account price changes, such as inflation or deflation, by comparing current year prices to a given base year. (ILO, 2023)

Labor productivity can be assessed by measuring Real GDP per unit of labor input, which provides insights into productivity growth, efficiency, and the quality of human capital in the production process. Economic growth in a country can be attributed to either an increase in the amount of labor input or improved efficiency of those employed. This indicator specifically focuses on the latter aspect, making it a crucial measure of economic performance. (ILO, 2023)

Estimations of labor productivity can aid in the development of labor market policies and assess their impact, while also enhancing our comprehension of how labor market performance influences living standards. (ILO, 2023)

2.2.3.2 INFORMAL EMPLOYMENT

Informality is a complex issue, with around 61.2% of global employment

consisting of informal workers (Wirjo, 2022). In emerging economies and developing countries, the informal economy employs about 70% of workers, reaching nearly 90% in sub-Saharan Africa and South Asia. (GIZ, 2020)

The informal economy provides job opportunities and income for those lacking formal employment, enabling youth to enter the labor market. However, it carries the risk of poverty due to low wages and lack of social security. (GIZ, 2020)

Despite its challenges, the informal sector contributes significantly to the economy, such as between 8.2% and 56.6% of GDP in APEC economies. Informal workers present an opportunity for governments to boost tax revenues if formalized, as around USD 3.1 trillion or 5% of global GDP is lost due to tax evasion from informality. (Wirjo, 2022)

Digitalization has the potential to transform the informal sector by providing new skills and improving livelihoods. Simple technologies like tracking goods, making payments, and accessing to financing can benefit informal business owners without complex digital requirements. Informal online commerce on platforms like Facebook offers opportunities for informal business owners to reach customers and market their products. (Antoine, 2022)

Encouraging formal registration, implementing digital payments or financial access, reinforcing laws, promoting literacy, expanding market reach and creating awareness can achieve Sustainable Development Goals, eradicate poverty and foster youth development through digitalization.

Digitalization also connects skilled labor of the informal sectors to access global work opportunities (Antoine, 2022). It also offers possibilities for a gradual shift towards formalization by enhancing productivity and improving working conditions for informal economy workers. (GIZ, 2020)

On the other hand, the impact of digitalization on developing countries is uncertain, and its effect on labor cannot be accurately predicted, and marginalized groups face a higher risk of exclusion from digitalization's opportunities. (GIZ, 2020)

Challenges like the digital divide, cybersecurity, and competition need to be addressed. Digitalization can provide pathways for transitioning to the formal sector, but it does not guarantee direct causal effects and may even encourage movement from formal to informal sectors. Policymakers must consider diverse interventions tailored to their economy's characteristics. (Wirjo, 2022)

In this research, it is considered the SDG indicator 8.3.1, which focuses on the

Proportion of informal employment in total employment in non-agricultural activities. Employment refers to individuals of working age who were either engaged in paid employment (whether actively working or having a job but not currently working) or self-employment (whether actively working or having a business but not currently working) during a specific short period. (ILO, 2023)

Informal employment refers to a type of work where employees do not have legal protection or access to labor rights and benefits. It is characterized by the absence of coverage under national labor legislation, limited or no income taxation, inadequate social protection, the absence of certain employment benefits, and the absence of a written employment contract. (ILO, 2023)

Informal employment includes individuals who, in their primary or secondary jobs, fall into the following categories: (ILO, 2023)

- a. Self-employed workers, employers, and members of producers' cooperatives working in their own informal sector businesses.
- b. Producers who create goods exclusively for their own household's personal consumption (e.g., subsistence farming).
- c. Contributing family workers, regardless of whether they work in formal or informal sector businesses.
- d. Employees with informal jobs, regardless of whether they are employed by formal sector businesses, informal sector businesses, or as paid

domestic workers by households.

Informal businesses are characterized by not being legally separate from the owners, engaging in market transactions, and having a lack of registration or employees who are not registered, or a limited number of employees. (ILO, 2023)

2.2.3.3 EMPLOYEE EARNINGS

The impact of technology on the labor market is complex, and it may lead to rising wages for some workers while causing others, including the median worker, to face stagnant or even falling wages as their skills become obsolete. The slow pace of adaptation by training institutions and labor markets to new technologies exacerbates this challenge by leading to a lack of standardized technical skills and training. (Bessen, 2015)

This situation forces many workers to learn on the job, without sufficient incentives from employers, resulting in a limited supply of highly skilled workers and growing economic inequality within occupations. One example of this is the graphic design industry, the demand for web and mobile designers has increased with new technologies, but most graphic arts schools still focus on print design, leading to limited wage growth for the median designer. the

most talented designers can command high salaries by teaching themselves new skills and establishing reputations. (Bessen, 2015)

The same pattern is seen in office and healthcare jobs, where the top 10 percent of workers with valuable skills experience faster wage growth than the average worker. Similarly, experienced workers and college graduates in computer-related jobs earn higher wages than new hires and high school graduates. (Bessen, 2015)

All of these examples demonstrate that while employers offer higher pay to workers with specific computer-related skills, the average worker finds it challenging to gain the necessary knowledge of new technologies. Therefore, there is a need for training institutions and the labor market to be more effective in keeping up with ever-changing technology. (Bessen, 2015)

This study refers to the SDG indicator 8.5.1, which focuses on the Average hourly earnings of employees. However, due to the lack of data for the years of study in many countries, the harmonized data Average monthly earnings of employees are used according to the 19th ICLS standards in US dollars using market exchange rates or using 2017 purchasing power parities (PPPs). (ILO, 2023)

In the context of wage statistics, earnings refer to the total gross compensation, including both cash and non-monetary forms, that employees receive at regular intervals for their work or time spent on tasks. This compensation encompasses remuneration for both actual working hours and non-working hours, such as annual vacations, other types of paid leave, or holidays. (ILO, 2023)

However, earnings do not include the contributions made by employers to social security and pension schemes on behalf of their employees, nor do they encompass the benefits received by employees through these schemes. Additionally, severance and termination pay are excluded from the calculation of earnings. (ILO, 2023)

2.2.3.4 UNEMPLOYMENT

Since the First Industrial Revolution, there has been a constant social fear of technological unemployment. This fear was first sparked by the idea of an automatic factory, followed by the introduction of information technologies and the internet, and now with the robotization and digitalization of production. John Maynard Keynes' prediction in 1933 that technological innovations would lead to greater unemployment than the creation of new jobs has been revived as a result. (UGT Castilla y León, 2018)

The Fourth Industrial Revolution has brought media attention to the rapid and future technological unemployment resulting from the replacement of human labor skills with new technologies of robotization and digitalization, rendering human contributions irrelevant in production processes. (UGT Castilla y León, 2018)

Digitalization will involve a fundamental substitution automation, where technological innovations of the Fourth Industrial Revolution will significantly replace human labor in many occupations, leading to social disruption. Occupations with routine tasks requiring lower educational levels, less organizational responsibility, and easily codifiable procedures for computers and programmable robots will be at the highest risk of job loss. (UGT Castilla y León, 2018)

As a result, the automation process and the subsequent technological unemployment will be more severe in various branches of the industrial and service sectors, with standardized production processes and low cognitive content in human labor tasks (UGT Castilla y León, 2018). Manufacturing lost 5 million jobs in 30 years, but other sectors compensated with employment growth (Bessen, 2015).

Despite countless technological innovations that have resulted in organizational

changes, changes in human labor skills, and changes in production processes due to increased capital or technological investment, global employment has not decreased but has increased regularly in the more than nine decades since Keynes' prediction. (UGT Castilla y León, 2018)

For instance, the widespread adoption of ATMs in the USA since 1970, bank teller jobs have not decreased. ATMs reduced the cost of operating a bank branch, but banks opened more branches, requiring more tellers. Also, remaining non-automated tasks became more valuable, emphasizing the importance of interaction skills of bank tellers. (UGT Castilla y León, 2018)

According to Gregory, Salomon, and Zierhan (2017), who analyzed data from 1993 to 2007, 9.6 million jobs were lost in Europe due to direct substitution by automation. However, they also found that 8.7 million jobs were created as a result of the general increase in demand for human labor, and an additional 12.4 million jobs were created due to the multiplier effect of the salaries earned in other productive sectors. Therefore, despite the impact of automation, a total of 11.4 million jobs were created during that period. (UGT Castilla y León, 2018), (Bessen, 2015)

Therefore, while professions, trades, or jobs have disappeared due to technological obsolescence, they have been replaced by the emergence of new

jobs in new productive sectors or the production of new technological products. In other words, job destruction and creation have occurred through the reorganization of tasks and the management of new skills. (UGT Castilla y León, 2018), (Bessen, 2015)

The Fourth Industrial Revolution is not only changing the economy, but also disrupting the labor market through the introduction of new technologies. Automation has historically destroyed jobs before creating new ones, but the difference now is that the revolution is impacting cognitive abilities rather than physical strength and skills. This has raised concerns about the potential impact of digital competitiveness on the job market. (CCOO industria, 2017)

For Larsson and Teigland, 2016 OECD report suggest that the impact of digitalization on the future of labor is uncertain. While it is suggested that technological change may save labor, it is also argued that new jobs have not replaced old ones on a large scale. However, A 2018 OECD report states that digitalization and automation do not pose a significant risk of job destruction, but tasks will change significantly. This has implications for welfare systems that rely on labor taxation for revenue. (Larsson & Teigland, 2020)

According to Wiskirchen, mass unemployment can cause human disasters and migration surges, affecting developing and developed nations alike. Low and

medium-skilled jobs will be lost, especially in developing countries where routine positions dominate. For example, US faces 47% job risk, while Thailand and India face a 70% risk. (Wisskirchen, 2017)

At present, the cost of implementing (partially) autonomous systems outweighs labor costs in several sectors. Companies in developing countries must invest in appropriate systems to improve productivity, competitiveness and attractivity. However, with production robots becoming cheaper each year, it will be economically sensible to replace human labor with robots in low-labor-cost countries when human labor costs 15% more than robotic labor. (Wisskirchen, 2017)

This research examines SDG indicator 8.5.2, which focuses on the Unemployment rate. The unemployment rate represents the percentage of individuals who are unemployed in relation to the total labor force, which includes both the employed and unemployed individuals (ILO, 2023)

However, employment rate is the percentage of employed persons in relation to the total population in working age (includes individuals not in the labor force). Therefore, the unemployed category consists of all individuals of working age who meet the following criteria: (ILO, 2023)

- a. They were not engaged in paid employment or self-employment during

the reference period.

- b. They were available for work, indicating their readiness to engage in paid employment or self-employment during the reference period.
- c. They actively seek employment by taking specific actions within a specified recent period comprising the last four weeks or one month to find paid employment or self-employment.

The unemployment rate measures underutilization of labor supply, reflecting an economy's inability to generate employment for job seekers. It indicates labor market efficiency and effectiveness. (ILO, 2023)

2.3 DEFINITION OF TERMS

- **Digital Competitiveness:** The capacity of an economy to adopt and explore digital technologies leading to the transformation in government practices, business models and society in general.
- **Digital transformation:** Organizational change and implementation of digital technologies during the Fourth Industrial Revolution.
- **Digitalization:** Adoption or increasing the use of digital technology to change a business model and provide new revenue and value-producing opportunities.
- **Employee Earnings:** Cash and non-monetary compensation for work and non-work hours, but excluding certain contributions and benefits.
- **Employment:** Individuals of working age (usually 15 and above) who were involved in any paid or profitable activity during a specified reference period.
- **Fourth Industrial Revolution:** Continuous development and accelerated global expansion of new technologies due to increasing interconnectivity and smart automation. Popularized in 2015 by Klaus Schwab, the World Economic Forum founder and executive chairman.
- **Impact:** The effect or influence that something has on somebody/something.
- **Indicators:** Measurement or value which gives you an idea of what something is like.
- **Informal economy:** Refers to all economic activities performed by

individuals and entities that are not adequately covered by formal regulations, either legally or in practice.

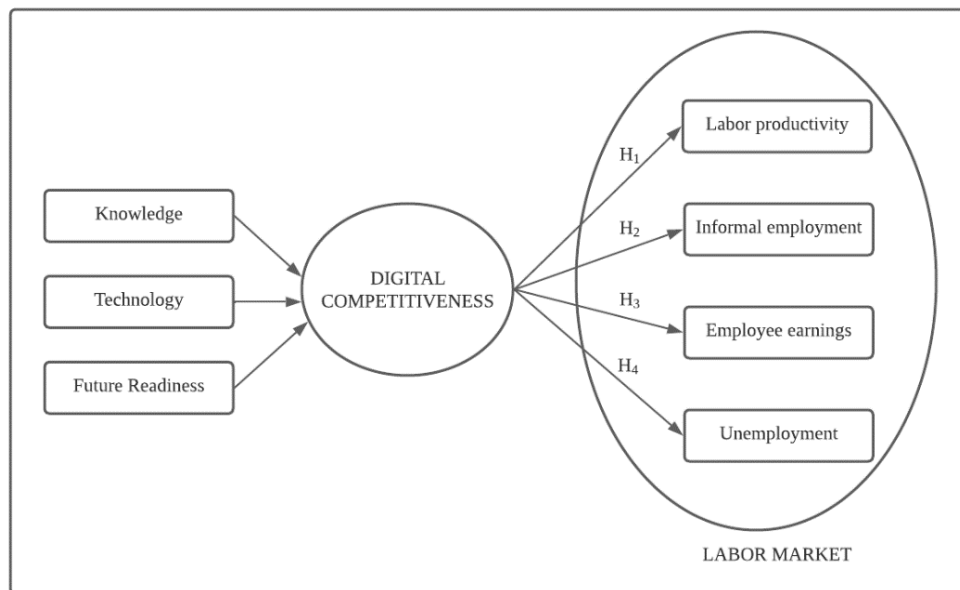
- **Informal Employment:** Jobs where workers are not protected by national labor laws, income taxation, social protection, or certain employment benefits.
- **Labor market:** Interaction between workers and employers. According to the SGD, it is measured through indicators such as labor productivity, informal employment, employee earnings, and unemployment.
- **Labor Productivity:** It is the measurement of Real GDP per unit of labor input, providing insights into productivity growth, efficiency, and human capital quality in the production process.
- **Real GDP:** Adjusted measure of the monetary value of goods and services purchased by the final user, accounting for price changes over time.
- **Unemployment:** Individuals who were not employed, available for work, and actively seeking employment during a specified period.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 RESEARCH MODEL

According to the literature review, with the study variables the following research model is elaborated:

Figure 1: *Research model between Digital competitiveness and labor market*



Fourth Industrial Revolution from 2017 to 2021

Note. H₁, H₂, H₃, H₄ are the specific hypothesis.

Source: Self-created

The IMD World Digital Competitiveness Ranking assesses the ability of countries to adopt and explore digital technologies for competitiveness. The relationship between digital competitiveness and labor market indicators, including labor productivity, informal employment, employee earnings, and unemployment, is multifaceted:

1. Labor Productivity

Higher digital competitiveness often correlates with increased labor productivity. Advanced digital technologies can automate routine tasks, enhance efficiency, and optimize workflows, contributing to higher productivity levels. Digital competitiveness may lead to a demand for a more skilled workforce, as employees need to adapt to and utilize digital tools. This can further boost productivity in industries that effectively leverage digital technologies.

2. Informal Employment

The impact on informal employment can be mixed. On one hand, digital technologies and platforms may facilitate the growth of the economy, creating more opportunities for informal work. On the other hand, the formalization of certain industries through digitalization may reduce informal employment. Informal workers may face challenges in adapting to digital tools, which could increase existing differences in skills and access to technology.

3. Employee Earnings

As digital competitiveness increases, there is a likelihood of a higher demand for digital skills. Employees with these skills may command higher earnings due to their ability to contribute to the digital transformation of businesses. The digital divide can contribute to income inequality, as those with access to digital education and resources may experience greater wage growth compared to those without.

4. Unemployment

The digitalization of industries can lead to job displacement for roles that can be automated. However, it can also create new opportunities in emerging fields related to digital technologies, potentially balancing out unemployment rates. Unemployment may persist or even rise if there is a significant gap between the skills demanded by the digital economy and the skills possessed by the workforce.

In short, the relationship between Digital Competitiveness and Labor market indicators is dynamic and complex. While increased digital competitiveness can positively impact labor productivity and employee earnings, it may also contribute to challenges such as informal employment and unemployment, particularly if there is a mismatch in skills.

As mentioned, the following research hypotheses are formulated.

3.2 RESEARCH HYPOTHESIS

3.2.1 GENERAL HYPOTHESIS

The Digital Competitiveness has a significant impact on labor market indicators during the Fourth Industrial Revolution from 2017 to 2021.

3.2.2 SPECIFIC HYPOTHESIS

H₁: The Digital Competitiveness directly affects labor productivity during the Fourth Industrial Revolution from 2017 to 2021.

Studies have shown that countries with higher digital competitiveness tend to have higher levels of labor productivity. As proof, in 2019, a study by the World Economic Forum found that countries in the top 10% of the Global Competitiveness Index also had the highest levels of labor productivity. Digital technologies can automate many tasks, which can free up workers to focus on more complex and value-added activities. This can lead to higher labor productivity. Digital technologies can also connect workers to new markets and opportunities, which can also boost productivity.

H₂: The Digital Competitiveness indirectly affects informal employment during the Fourth Industrial Revolution from 2017 to 2021.

Digital technologies can create new opportunities for entrepreneurship and self-employment. This can help to reduce informal employment. Digital technologies can also make it easier for informal workers to connect with formal businesses and markets. This can help them to formalize their work and increase their earning potential. However, digital technologies can also lead to the displacement of informal workers, especially those in low-skilled jobs. This can exacerbate informality and poverty.

H₃: The Digital Competitiveness directly affects employee earnings during the Fourth Industrial Revolution from 2017 to 2021.

Studies have shown that workers in digital occupations tend to earn higher wages than workers in non-digital occupations. For example, a 2021 study by the Pew Research Center found that median hourly wages for workers in digital occupations were 15% higher than for workers in non-digital occupations. Digital technologies can make it easier for workers to find high-paying jobs. To give an example, online job boards and social media can connect workers with employers from around the world; although, digital technologies can also lead to the polarization of the labor market, with a widening gap between high-paying and low-paying jobs. This can reduce the earnings of low-skilled workers.

H4: The Digital Competitiveness indirectly affects unemployment during the Fourth Industrial Revolution from 2017 to 2021.

Studies have shown that countries with higher digital competitiveness tend to have lower levels of unemployment. In particular, a 2018 study by the International Monetary Fund found that a 10% increase in digital competitiveness is associated with a 0.6% decline in unemployment. Digital technologies can create new jobs in the digital economy. For instance, the growth of e-commerce and social media has created many new jobs in the IT and telecommunications sectors. At the same time, digital technologies can also lead to job displacement, as automation and artificial intelligence make some jobs obsolete. This can exacerbate unemployment, especially among low-skilled workers.

3.3 IDENTIFICATION OF VARIABLES

3.3.1 INDEPENDENT VARIABLE

Digital Competitiveness

3.3.2 DEPENDENT VARIABLE

Labor market indicators: labor productivity, informal employment, employee earnings, and unemployment

3.4 VARIABLES OPERATIONALIZATION

VARIABLE	INDICATORS	ABBREVIATION	DEFINITION	MEASUREMENT	
Digital Competitiveness	Knowledge	KN	Know-how necessary to discover, understand and build new technologies.	<ul style="list-style-type: none"> • Talent • Training and Education • Scientific Concentration <p>These nine sub-factors comprise 54 criteria, it can be hard data (weight 2/3) or soft data (weight 1/3).</p>	
	Technology	TE	Overall context that enables the development of digital technologies.		<ul style="list-style-type: none"> • Regulatory Framework • Capital • Technological Framework
	Future Readiness	FR	Level of country preparedness to exploit digital transformation.		<ul style="list-style-type: none"> • Adaptive Attitudes • Business Agility • IT Integration
Labor market	Labor productivity	LP	SDG Indicator 8.2.1: Annual growth rate of real GDP per employed person.	<p>First, GDP per employed person is obtained by dividing the GDP for that year by the number of employed persons in the country in the same year</p> <p>Then, indicator is calculated as follows:</p> $GEP_t^{GDP} = \frac{LP_t - LP_{t-1}}{LP_{t-1}} \times 100$ <ul style="list-style-type: none"> • GEP_t^{GDP}: Annual growth rate per employed person of real GDP for the year t • LP_t: Real GDP per employed person (labor productivity) at constant base year prices for the year t • LP_{t-1}: Real GDP per employed person (labor productivity) at constant base year prices for the year t-1. 	

	Informal employment	IE	SDG indicator 8.3.1: Proportion of informal employment in total employment in non-agricultural activities.	The following calculation is used: $\frac{\text{Informal employment in non – agricultural activities}}{\text{Total employment in non – agricultural activities}} \times 100$
	Employee earnings	EE	SDG indicator 8.5.1: Average hourly earnings of employees (due to the lack of data, the harmonized data Average monthly earnings of employees is used)	To harmonize the data the following conversions is applied: <ul style="list-style-type: none"> • Hourly earnings are multiplied by actual weekly hours worked (if available) for each gender for monthly earnings and then multiplied by 4.33 weeks • Daily figures are multiplied by 5 or 6 days (depending on income group) and 4.33 weeks • Weekly figures are multiplied by 4.33 weeks • Annual figures are divided by 12 months <p>Data are converted to U.S. dollars as the common currency, using exchange rates or using purchasing power parity (PPP) rates for private consumption expenditures.</p>
	Unemployment	UN	SDG indicator 8.5.2: Unemployment rate. Individuals who were not employed, available for work, and actively seeking employment during a specified period.	The unemployment rate (U) is calculated as following: $U = \frac{\text{Number of unemployed persons}}{\text{Persons employed} + \text{Persons unemployed}} \times 100$

3.5 RESEARCH TYPE AND DESIGN

TYPE: Exploratory

DESIGN: Multivariate predictive analysis

3.6 RESEARCH POPULATION AND SAMPLE

3.6.1 POPULATION

Countries that are evaluated in the IMD World Digital Competitiveness Ranking by the IMD World Competitiveness Center from 2017 to 2021.

3.6.2 SAMPLE

The sample is non-probabilistic for convenience. It consists of 23 countries that satisfy the inclusion and exclusion criteria. Therefore, for the 5 years of study, the final result of the sample is 115.

Inclusion criteria:

- Countries that have complete data for both WDC factors (knowledge, technology, and future readiness) and SDG labor market indicators (labor productivity, informal employment, employee income and unemployment) from 2017 to 2021.

Exclusion criteria:

- Countries that do not have complete data on the WDC factors from 2017 to 2021.
- Countries that do not have complete data for the SDG labor market indicator from 2017 to 2021.

3.7 DATA COLLECTION INSTRUMENT

The methodology used for this research is based on the collection of secondary data sources from reliable sources. The data of the World Digital Competitiveness factors was obtained from the website of the IMD World Competitiveness Center (IMD, 2023). Data of the Labor market indicators were taken from the website of the International Labor Organization, in the database named SDG Labor Market Indicators (ILOS DG) (ILOSTAT, 2023).

3.8 DATA PROCESSING AND ANALYSIS TECHNIQUES

The Microsoft Excel 2019 program was used for collection and process data, and the SmartPLS 4.0 to analyze the data. This is path modeling software based on the second-generation multivariate methods for exploratory (predictive) studies. The technique used is structural equation modeling (SEM) using the partial least squares (PLS) method. (Martinez & Fierro, 2018)

The following steps were followed:

1. Collection of data according to the variables of the research.
2. Data processing according to the inclusion and exclusion criteria.
3. Analysis and interpretation of the results are carried out according to the three-phase methodology: (Ramirez, 2014)
 - a. Phase 1: description of the structural (relationship between latent variables-LV) and measurement model (variables and indicators).
 - b. Phase 2: validity and reliability of the measurement model.
 - Internal validity (formative indicators): Variance Inflation Factor (VIF<10)
 - Individual reliability: loading ($\lambda \geq 0.55$).
 - Construct reliability: Cronbach's Alpha Coefficient (CA>0.7) and Construct Composite Reliability (CR>0.7).
 - Convergent validity (reflective indicators): Average Variance Extracted (AVE>0.5).
 - Discriminant validity: square root of AVE of each LV > Pearson correlations of the rest of LV.
 - c. Phase 3: structural model assessment
 - Bootstrapping: 5000 bootstraps (subsamples), two tailed and significance level 0.05.
 - Variance of the endogenous variable: explained variance ($R^2 \geq 0.1$).
 - Global adjustment: goodness of fit (GoF ≥ 0.5).

- Path coefficient ($\beta \geq 0.2$).
4. Results are displayed in an organized manner by presenting them in tables and figures according to their corresponding outcomes.

CHAPTER 4: DATA ANALYSIS AND RESULTS

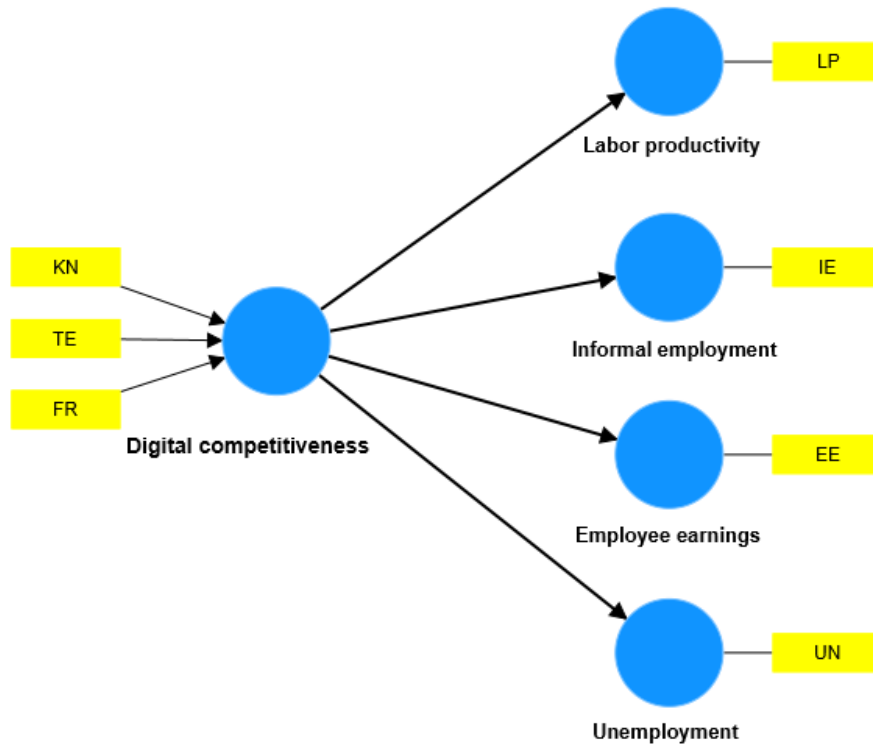
4.1 RESULTS OF THE DESCRIPTIVE MODEL

Data was analyzed using SmartPLS 4.0 to perform partial least squares structural equation modelling (PLS-SEM) to test the hypothesized relationships among the constructs (latent variables) in the proposed Model depicted (Figure 1). PLS-SEM was deemed most appropriate because of the predictive focus of the study. Also, the study was meant to explore the measures of a relatively new concept which is the Digital competitiveness during the Forth industrial revolution.

In Figure 2, the path modeling of the latent variable Digital Competitiveness with its formative indicators (Knowledge - KN, Technology - TE, and Future Readiness - FR) is depicted, illustrating its relationship with four other latent variables: Labor Productivity (LP), Informal Employment (IE), Employment Earnings (EE), and Unemployment (UN).

Figure 2

Graphic description of the model between Digital competitiveness and labor market indicators



Note. Circles are the latent variables and rectangles are indicators of each variable.

Source: Self-generated using SmartPLS.

4.2 RESULTS OF THE VALIDITY AND RELIABILITY OF THE MEASUREMENT MODEL

To ensure internal validity of Digital Competitiveness with formative indicators, multicollinearity was evaluated by calculating VIF using regression analysis. The value of Digital competitiveness was equal to 1, its internal validity is accepted; for the indicators, VIF is less than 10. In addition, in Table 1 it can be seen that all the loads/weights of the indicators are greater than 0.7, so individual reliability is accepted. The model contains only formative and single-item constructs, so there is no other validity and reliability analysis.

Table 1: *Loads, weights and VIF values*

Latent variable	Indicators	Loads	Weights	VIF
Digital competitiveness	KN	0.982	0.605	6.221
	TE	0.930	0.088	6.253
	FR	0.946	0.343	5.023
Labor productivity	LP	1.0	1.0	1.0
Informal employment	IE	1.0	1.0	1.0
Employee earnings	EE	1.0	1.0	1.0
Unemployment	UN	1.0	1.0	1.0

Source: Self-generated using SmartPLS.

4.3 RESULTS OF THE STRUCTURAL MODEL ASSESSMENT

Table 2 presents the variance of the endogenous variables such as Labor productivity, Informal employment, Employee earnings and Unemployment, their R² are 0, 0.455, 0.506 and 0.214 respectively, the Digital competitiveness variable does not explain any variance in the Labor productivity variable.

Also, it is shown in Table 2 the Q² predict with RMSE and MAE values for Informal employment, Employee earnings and Unemployment, those are 0.444, 0.488 and 0.194 respectively, but for Labor productivity suggests that the model's predictions are less accurate than random guessing (-0.012).

Table 2: *Model Fit and Predictive Relevance*

Latent variable	R ²	Q ² predict	RMSE	MAE
Labor productivity	.0	-.012	1.03	0.785
Informal employment	.455	.444	0.759	0.637
Employee earnings	.506	.488	0.724	0.526
Unemployment	.214	.194	0.917	0.668

Note. RMSE (Root Mean Square Error) and MAE (Mean Absolute Error)

Source: Self-generated using SmartPLS.

Table 3 presents the path coefficients (β), statistical significance obtained through Bootstrapping, and confidence intervals (2.5%-97.5%). The results indicate that there is an indirect effect but statistically no significant between Digital

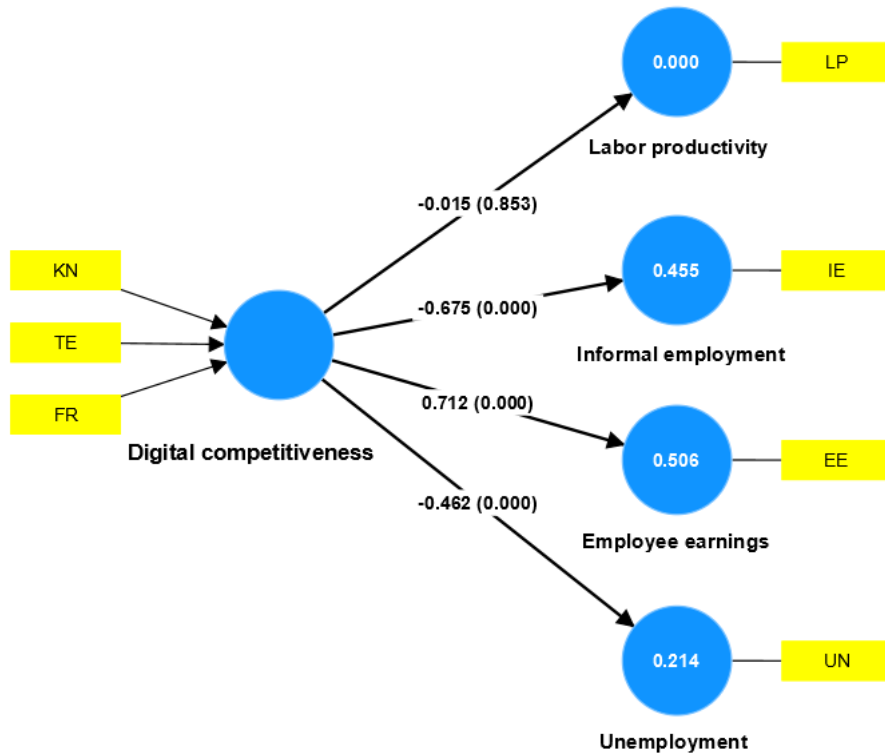
competitiveness and Labor productivity ($\beta=-.015$, $t=0.185$, $p=0.853$). However, there is a statistically significant indirect relationship between Digital competitiveness on Informal employment ($\beta=-.675$, $t=14.181$, $p<.001$) and Unemployment ($\beta=-.462$, $t=6.212$, $p<.001$). In other words, if the independent variable increases, the dependent variable is expected to decrease. Additionally, there is a statistically significant direct relationship between Digital competitiveness on Employee earnings ($\beta=.712$, $t=16.678$, $p<.001$). This indicates that as Digital competitiveness increases, the employee earnings are expected to increase as well. Figure 3 summarizes in the path modeling what is mentioned.

Table 3: *Path coefficients and statistical significance*

Independent variable	Dependent variable	β	t-value	p-value	2.5%	97.5%
Digital competitiveness	Labor productivity	-.015	0.185	.853	-0.178	0.15
Digital competitiveness	Informal employment	-.675	14.181	.001	-0.76	-0.575
Digital competitiveness	Employee earnings	.712	16.678	.001	0.632	0.797
Digital competitiveness	Unemployment	-.462	6.212	.001	-0.601	-0.314

Source: Self-generated using SmartPLS.

Figure 3: *Final results of path modeling*



Source: Self-generated using SmartPLS.

Based on the values mentioned above, Table 4 presents the results for hypotheses H₂, H₃, and H₄, demonstrating statistically significant relationships between the variables. However, hypothesis H₁ is not supported, as there is no significant evidence to suggest a relationship between the variables based on the findings.

Table 4: *Final result of the hypothesis*

Hypothesis	Independent variable	Dependent variable	Results
H ₁	Digital competitiveness	Labor productivity	Not Supported
H ₂	Digital competitiveness	Informal employment	Supported
H ₃	Digital competitiveness	Employee earnings	Supported
H ₄	Digital competitiveness	Unemployment	Supported

Source: Self-generated using SmartPLS.

4.4 DISCUSSION OF RESULTS

The discussion of results focuses on the impact of digital competitiveness on the labor market during the Fourth Industrial Revolution, specifically analyzing the variables of labor productivity, informal employment, employee earnings, and unemployment. The literature review and the results provide insights from various studies conducted in different countries, offering a comprehensive understanding of the relationship between digital competitiveness and labor market outcomes.

Labor productivity is a crucial measure of efficiency for companies, and the implementation of digital technologies has a significant impact on it. Several studies highlight the positive association between digitalization and labor productivity.

The literature review provides insights into the relationship between digitalization

and labor productivity. According to Varlamova and Larionova (2020), implementing information and communication technologies (ICT) can significantly impact labor productivity by improving business processes, reducing transaction costs, and enhancing resource utilization. Research in EU countries and transition economies demonstrates that ICT components have a positive effect on labor productivity. Additionally, the World Economic Forum recognizes the ICT sector as a significant contributor to output growth (Aly, 2020).

However, the replacement of human jobs with robots or artificial intelligence raises concerns. While digitization enhances productivity and growth in developed economies, it can lead to job displacement and outsourcing of lower-skill work. The impact of digitalization on employment is more pronounced in emerging markets, where it positively affects job creation and exports. Efforts to address these challenges include considering changes in the tax system and introducing tariffs on robots to compensate for employment losses. However, implementing such measures raises questions about their potential impact on the high-tech market and competitiveness.

The current study did not find a statistically significant indirect effect between digital competitiveness and labor productivity. This may indicate that other factors not considered in the analysis could be influencing labor productivity. Further research could explore additional variables and factors that may influence the relationship

between digital competitiveness and labor productivity.

Informal employment, a significant component of the labor market, presents both opportunities and challenges. The informal sector employs a substantial portion of the global workforce, particularly in emerging economies and developing countries. Digitalization has the potential to transform the informal sector by providing new skills, improving livelihoods, and offering opportunities for formalization. Simple digital technologies can benefit informal business owners, enabling them to track goods, make payments, access financing, and reach customers through online platforms. The formalization of the informal sector can contribute to tax revenues and reduce tax evasion (Antoine, 2022).

This aligns with the findings of the current study, which identified a statistically significant indirect impact of digital competitiveness on informal employment. The results suggest that digitalization can contribute to formalization efforts and improve working conditions for informal economy workers (GIZ, 2020). However, it is important to address challenges such as the digital divide and ensure that marginalized groups are not excluded from the benefits of digitalization (GIZ, 2020).

According to Employee earnings, Bessen (2015) highlights that while workers with specific computer-related skills may earn higher wages, the average worker faces challenges in acquiring the necessary knowledge of new technologies. This aligns

with the findings of the current study, which identified a statistically significant direct impact of digital competitiveness on employee earnings. The results suggest that digital competitiveness can lead to higher earnings for employees. However, it is crucial to address the skills gap and ensure that training institutions and the labor market keep pace with technological advancements to avoid growing economic inequality within occupations (Bessen, 2015).

Unemployment is another crucial aspect of the labor market affected by digital competitiveness. Research findings from different countries reveal varied relationships between digital technology indexes and unemployment rates. Abbasabadi and Soleimani (2021) found a significant polynomial relationship between technology indexes and unemployment, suggesting that unemployment initially rises and then declines as digital technology expands. Boorish (2022) also observed a negative and significant impact of ICT on employment in Gulf Cooperation Council countries.

The findings of the current study align with the literature, as they indicate a statistically significant indirect impact of digital competitiveness on unemployment. This implies that as digital competitiveness increases, it can lead to changes in the labor market and potentially influence unemployment rates.

Finally, the results discussed in the thesis demonstrate the complex and multifaceted

relationship between digital competitiveness and labor market outcomes. Digitalization has the potential to enhance labor productivity, transform the informal sector, and create new employment opportunities. However, it also poses challenges related to job displacement, inequality, and exclusion. Future research and policy efforts should focus on addressing these challenges and maximizing the benefits of digitalization while ensuring inclusivity and equitable distribution of its advantages across different sectors and populations.

CHAPTER 5: CONCLUSIONS

5.1 CONCLUSIONS

In the context of the Fourth Industrial Revolution, this study found the impact of the Digital competitiveness on various labor market indicators, including labor productivity, informal employment, employee earnings, and unemployment. The results provide robust evidence, indicating the following:

1. There is an indirect effect between Digital competitiveness and Labor productivity, although it is not statistically significant ($\beta=-.015$, $t=0.185$, $p=0.853$). This means that the evidence is not strong enough to conclude that Digital Competitiveness may have a small negative impact on Labor productivity. More research is needed to confirm or refute this relationship.
2. There is a statistically significant indirect impact of Digital competitiveness on Informal employment ($\beta=-.675$, $t=14.181$, $p<.001$). It is interpreted that if Digital Competitiveness improves, Informal employment tends to decline, suggesting that digitalization may contribute to formalizing informal labor markets and enhancing economic inclusion.

3. There is a statistically significant direct impact of Digital competitiveness on Employee earnings ($\beta=.712$; $t=16.678$, $p<.001$). It suggests that countries with higher levels of Digital Competitiveness can expect their employees to earn higher wages on average. This implies that digitalization efforts can potentially contribute to higher living standards and a more equitable distribution of income.

4. There is a statistically significant indirect impact of Digital competitiveness on Unemployment ($\beta=-.462$, $t=6.212$, $p<.001$). The statement implies that countries with higher levels of Digital Competitiveness can expect lower Unemployment rates, so digitalization can potentially contribute to create new jobs and opportunities for workers.

Overall, these results provide valuable insights for governments, policymakers, organizations or stakeholders to develop policies and strategies to ensure that the benefits of digitalization are shared widely and equitably.

5.2 RECOMMENDATIONS

The following recommendations can be made for this thesis:

1. Enhance digital skills and literacy: Given the impact of digital competitiveness on labor market indicators, it is crucial to prioritize efforts in enhancing digital skills and literacy among the workforce. This can be achieved through targeted training programs, workshops, and educational initiatives that equip individuals with the necessary knowledge and abilities to thrive in the digital era.
2. Foster innovation and technological adoption: The Fourth Industrial Revolution presents opportunities for innovation and technological advancements. Policymakers, organizations, and individuals should actively embrace and adopt emerging technologies to improve productivity and competitiveness. Encouraging research and development, providing incentives for technology adoption, and fostering a culture of innovation can all contribute to a more digitally competitive labor market.
3. Address the challenges of informal employment: The study highlighted the impact of digital competitiveness on informal employment. Policymakers should focus on creating an enabling environment that promotes formal

employment and provides adequate social protection for workers. This can include implementing labor market regulations, offering incentives for formal job creation, and supporting entrepreneurship initiatives that transition informal workers into formal sectors.

4. Monitor and mitigate unemployment risks: While digital competitiveness can drive productivity and growth, it can also lead to job displacement in certain sectors. It is important for policymakers to closely monitor unemployment trends and develop appropriate measures to mitigate the negative effects. This can involve implementing effective social safety nets, facilitating job matching and reintegration programs, and fostering entrepreneurship and self-employment opportunities.

By implementing these recommendations, policymakers, organizations, and individuals can better navigate the challenges and leverage the opportunities presented by the Fourth Industrial Revolution, ultimately creating a more digitally competitive and inclusive labor market.

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APPENDICE

Data of the sample variables

N°	COUNTRY	YEAR	RANK	TOTAL_SCORE	GDP_EMPLOYED	INFORMATION_EMPLOY	MONTHLY_EARN	UNEMPLOYMENT
1	Finland	2017	4	95.03	2.18	8.70	3451.18	8.64
2	Netherlands	2017	6	93.23	1.03	14.20	4749.51	4.84
3	Australia	2017	15	85.01	0.02	28.20	3969.22	5.59
4	Austria	2017	16	84.12	1.06	4.20	3037.71	5.56
5	Luxembourg	2017	20	82.87	-2.55	2.70	5549.93	5.52
6	Ireland	2017	21	82.87	5.81	5.20	3600.59	6.71
7	Belgium	2017	22	80.77	-1.17	5.00	3552.85	7.09
8	France	2017	25	78.81	1.48	26.10	3483.94	9.41
9	Estonia	2017	26	78.46	3.62	3.20	1379.34	5.76
10	Lithuania	2017	29	75.02	4.13	6.40	949.38	7.07
11	Spain	2017	30	72.09	0.31	6.60	2226.60	17.22
12	Portugal	2017	33	69.67	0.24	7.70	967.01	8.87
13	Slovenia	2017	34	68.69	-0.33	7.70	1945.31	6.57
14	Latvia	2017	35	67.69	2.80	8.70	999.19	8.72
15	Italy	2017	39	65.47	0.50	10.30	2418.65	11.21
16	Greece	2017	50	54.42	-0.77	7.90	990.76	21.41
17	Turkey	2017	52	53.87	4.14	35.00	587.13	10.82
18	Cyprus	2017	53	53.50	2.02	14.10	2137.36	11.16
19	Brazil	2017	55	52.29	0.93	39.10	870.12	12.79
20	Jordan	2017	56	51.01	-0.84	44.70	497.30	18.12
21	Argentina	2017	57	49.80	2.32	48.30	874.86	8.35
22	Mongolia	2017	61	41.13	1.86	51.30	387.14	6.36
23	Peru	2017	62	41.08	-1.59	68.10	699.59	3.69
24	Finland	2018	7	95.25	-1.47	8.20	3646.79	7.36
25	Netherlands	2018	9	93.89	0.16	14.40	2967.74	3.83
26	Australia	2018	13	90.23	0.16	27.60	4467.33	5.30
27	Austria	2018	15	86.77	1.06	4.70	3268.88	4.93
28	Ireland	2018	20	84.29	5.87	5.70	3887.48	5.74
29	Belgium	2018	23	82.17	-0.63	5.30	3793.23	5.95

30	Luxembourg	2018	24	81.49	-0.93	7.30	5997.08	5.59
31	Estonia	2018	25	80.85	3.03	2.50	1547.05	5.37
32	France	2018	26	80.75	1.09	25.80	3704.65	9.02
33	Lithuania	2018	29	76.06	2.52	6.00	1091.32	6.15
34	Spain	2018	31	74.27	-0.24	5.90	2363.09	15.25
35	Portugal	2018	32	73.44	0.48	6.10	1048.69	6.99
36	Slovenia	2018	34	71.43	1.90	6.60	2099.74	5.13
37	Latvia	2018	35	69.17	2.67	8.50	1134.90	7.41
38	Italy	2018	41	64.96	0.04	12.00	2581.57	10.61
39	Jordan	2018	45	57.20	1.77	48.60	467.00	18.26
40	Turkey	2018	52	56.38	1.33	34.80	820.15	10.89
41	Greece	2018	53	56.29	-0.20	8.10	1046.39	19.18
42	Cyprus	2018	54	54.89	0.45	13.10	2289.87	8.50
43	Argentina	2018	55	54.16	-4.04	48.50	656.95	9.22
44	Brazil	2018	57	51.69	-0.07	39.60	782.20	12.33
45	Peru	2018	60	48.06	1.03	68.50	716.47	3.49
46	Mongolia	2018	61	48.06	5.49	48.80	405.62	5.38
47	Netherlands	2019	6	94.26	0.00	14.30	4870.67	3.38
48	Finland	2019	7	93.73	0.16	8.00	3518.51	6.69
49	Australia	2019	14	88.90	-0.17	26.40	3836.16	5.16
50	Ireland	2019	19	85.86	2.07	4.00	3818.72	4.95
51	Austria	2019	20	84.47	0.67	5.60	3187.14	4.56
52	Luxembourg	2019	21	84.37	-0.10	3.00	5814.77	5.59
53	France	2019	24	82.52	1.43	25.00	3563.29	8.41
54	Belgium	2019	25	82.49	0.49	3.90	5548.34	5.36
55	Spain	2019	28	78.74	-0.19	6.00	2726.83	14.10
56	Estonia	2019	29	78.67	3.37	6.20	1575.10	4.45
57	Lithuania	2019	30	77.58	4.88	5.50	1451.29	6.26
58	Slovenia	2019	32	75.17	3.57	7.30	2072.15	4.45
59	Portugal	2019	34	73.01	1.70	6.00	1858.58	6.46
60	Latvia	2019	36	72.44	2.75	7.70	1155.30	6.31
61	Italy	2019	41	67.90	-0.15	12.80	2453.89	9.95
62	Jordan	2019	50	60.40	-2.85	52.60	450.75	16.80
63	Turkey	2019	52	59.79	3.61	35.20	734.30	13.67
64	Greece	2019	53	59.63	-0.35	7.30	991.32	17.04
65	Cyprus	2019	54	59.54	2.03	11.90	2215.44	7.15
66	Brazil	2019	57	57.35	-1.11	39.90	735.33	11.94

67	Argentina	2019	59	56.04	-3.53	49.70	530.92	9.84
68	Peru	2019	61	54.03	-0.62	68.40	720.77	3.38
69	Mongolia	2019	62	49.85	-1.36	44.10	422.11	9.27
70	Netherlands	2020	7	92.57	-3.70	14.60	5200.11	3.82
71	Finland	2020	10	91.13	-0.81	6.50	3644.75	7.76
72	Australia	2020	15	85.47	-0.77	25.50	3874.30	6.46
73	Austria	2020	17	83.13	-5.29	4.50	4753.41	5.20
74	Ireland	2020	20	79.23	7.59	3.00	4105.28	5.62
75	Estonia	2020	21	78.03	2.10	8.30	1653.90	6.80
76	France	2020	24	76.98	-7.36	4.80	2302.15	8.01
77	Belgium	2020	25	76.98	-5.01	3.20	5760.27	5.55
78	Luxembourg	2020	28	73.27	-2.47	5.10	5892.34	6.77
79	Lithuania	2020	29	72.93	2.60	6.30	1631.74	8.49
80	Slovenia	2020	31	69.48	-3.48	6.90	2621.78	4.99
81	Spain	2020	33	68.99	-8.12	5.00	3000.21	15.53
82	Portugal	2020	37	66.51	-6.35	6.00	1086.23	6.80
83	Latvia	2020	38	65.50	-1.55	8.20	1258.70	8.10
84	Cyprus	2020	40	61.66	-4.75	11.60	2561.45	7.76
85	Italy	2020	42	60.91	-7.11	10.90	2520.83	9.16
86	Turkey	2020	44	59.82	7.58	31.40	706.53	13.11
87	Greece	2020	46	56.21	-7.99	7.40	1034.33	15.90
88	Brazil	2020	51	52.10	4.83	37.70	567.26	13.70
89	Jordan	2020	53	51.84	-3.15	53.50	453.14	19.21
90	Peru	2020	55	50.12	1.97	70.10	705.31	7.18
91	Argentina	2020	59	48.78	-2.31	46.80	514.35	11.46
92	Mongolia	2020	62	43.68	-1.32	43.40	433.87	6.59
93	Netherlands	2021	7	93.31	3.79	11.80	5521.70	4.21
94	Finland	2021	11	90.13	2.09	6.40	5128.85	7.61
95	Austria	2021	16	80.88	4.65	6.00	5057.22	6.46
96	Ireland	2021	19	79.16	9.09	2.10	5059.77	6.19
97	Australia	2021	20	78.68	0.94	26.10	4436.17	5.12
98	Luxembourg	2021	22	77.36	1.75	10.30	7860.33	5.25
99	France	2021	24	75.66	3.74	4.40	4561.81	7.86
100	Estonia	2021	25	75.42	6.87	9.10	2417.99	6.18
101	Belgium	2021	26	75.26	5.15	3.30	6133.37	6.26
102	Lithuania	2021	30	70.34	5.37	5.10	1747.02	7.11
103	Spain	2021	31	68.21	1.61	6.20	3067.07	14.78

104	Portugal	2021	34	65.18	4.88	9.70	2371.90	6.58
105	Slovenia	2021	35	64.97	6.51	7.70	2889.53	4.74
106	Latvia	2021	37	63.86	7.67	8.40	1860.72	7.51
107	Italy	2021	40	61.77	7.13	11.20	3640.27	9.50
108	Cyprus	2021	43	59.37	3.05	4.80	2716.56	7.51
109	Greece	2021	44	55.62	7.28	6.30	2286.84	14.66
110	Turkey	2021	48	52.84	4.40	29.90	454.83	11.98
111	Jordan	2021	49	52.52	-0.50	51.60	474.73	19.84
112	Brazil	2021	51	51.48	-0.82	39.20	447.55	13.16
113	Peru	2021	57	47.23	4.63	68.40	422.17	5.10
114	Argentina	2021	61	43.64	-1.51	48.90	544.82	8.74
115	Mongolia	2021	62	40.69	5.44	43.20	449.02	7.75