DIGITAL LITERACY AND MICROECONOMIC OUTCOMES: THE CASE OF KYRGYZSTAN

By

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Abstract

In this study, I will use the data from “Life in Kyrgyzstan,” the micro-level panel survey conducted in 2010-2013, 2016 and 2019 in the Kyrgyz Republic for 8,000 individuals and 3,000 households to examine if there is any correlation between digital literacy and microeconomic outcomes, such as employment and individual income. Implemented Fixed-Effect model, I controlled time-invariant factors which might lead to omitted variable bias. I found that individuals with basic digital literacy are associated with higher employment rates and individual income. This study has a significant role in enhancing educational policies and economic opportunities in the Kyrgyz Republic.

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Introduction

Schwab (2016) wrote that the Third Industrial Revolution or "the digital revolution" started in 1969 when people created the first electronics, computers and information technology which helped further automation of production. Nowadays humanity faces the Fourth Industrial Revolution with the invention of Artificial Intelligence[1].

As the First Industrial Revolution changed the requirements and expectations for workers and their skills in the eighteenth century, the Digital Revolution would change the requirements for modern employees (Schwab 2016). At the current time, employees are expected to have basic digital literacy skills, including proficiency with computers and office programs. (European Commission 2023). Nowadays, a typical employee's income depends on their digital literacy skills, particularly after the COVID-19 pandemic as remote and hybrid work became commonplace (Shirish et al. 2021). Moreover, the demand for IT developers, data analysts, data scientists, software engineers and other digital professionals increases every year[2].

All these tendencies in the labour market led to changes in the educational system and policies such as the initiative of the European Commission to add digital skills to the New Skills Agenda for Europe (European Commission 2016). The U.S. Department of Education's Office of Career, Technical, and Adult Education (OCTAE) implemented digital literacy initiatives to support citizens, including such vulnerable groups as prisoners, to support adults in learning STEM for further university and employment readiness[3].

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[1] Agbaji, D., Lund, B. D., & Mannuru, N. R. 2023. Perceptions of the Fourth Industrial Revolution and Artificial Intelligence Impact on Society. DOI:10.48550/arXiv.2308.02030. License: CC BY 4.0. University of North Texas.

[2] World Economic Forum. 2021. Future of Jobs Report 2020. https://www.weforum.org/reports/the-future-of-jobs-report-2020

[3] U.S. Department of Education, Office of Career, Technical, and Adult Education. "Digital Literacy Initiatives." LINCS, U.S. Department of Education. Accessed April 12, 2024. https://lincs.ed.gov/state-resources/federal-initiatives/digital-literacy#programs

Digital literacy has become one of the most critical issues for educational policies which can change economic outcomes at the micro-level, such as individual employment and income (Vuorikari et al. 2022). People are increasingly embracing these recent technologies, but in many countries, there are inequalities in access to digital technologies and digital literacy which is much more pronounced in developing countries [4]. The employment landscape is responsive to the rapid development of digital technologies, as more recent digital skills are of higher value[5]. This gap can affect the distribution of access to economic opportunities and overall social inequality (Philip et al. 2017), (Liu and Zhou 2023). Thus, the difference in economic outcomes between people with diverse levels of digital literacy can be even higher in developing countries and growing economies (World Bank 2016).

Kyrgyzstan is one of the former Soviet Union countries located in Central Asia which has been experiencing an economic transition and trying to adapt to the new digital era, modern technologies, and globalization (Windell et all 1995). The Kyrgyz Republic is one of the countries where this issue of digital literacy and its correlation with employment and income has not been investigated enough (Soltobaev 2020). Thus, in this thesis, I am going to understand the correlation between Digital Literacy and microeconomic outcomes in the Kyrgyz Republic.

Most of the population of the Kyrgyz Republic are rural residents since the country has only 2 large cities, Bishkek, and Osh[6]. Therefore, the issue of the digital divide between urban and rural populations is crucial for Kyrgyzstan (UNDP 2020). Understanding how digital literacy relates to microeconomic outcomes in such a context can help to create strategies to mitigate

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[4] Van Dijk, J. 2020. The digital divide. Journal of the Association for Information Science and Technology, 72(4). DOI:10.1002/asi.24355

[5] Westerman, G., Bonnet, D., & McAfee, A. 2014. Leading Digital: Turning Technology into Business Transformation. Harvard Business Review Press.

[6] "United Nations Development Programme. 2020. Kyrgyzstan National Human Development Report 2019: Sustainable Cities. Bishkek: UNDP Kyrgyzstan."

the digital divide and promote inclusive growth (World Bank 2016). Moreover, Kyrgyzstan has a micro-level panel survey "Life in Kyrgyzstan" (LIK) which can be a good potential source of data for the analysis[7].

I am going to explore the correlation between digital literacy and microeconomic outcomes such as employment and individual income in the Kyrgyz Republic. The results of the research will help to create implications for educational policy and allocation of resources. The analysis will aim to answer the following research questions "Is digital literacy associated with employment rates and individual income?."

For this research, I will use the Life in Kyrgyzstan survey which was conducted in 2010, 2011, 2012, 2013, 2016, and 2019 years in the Kyrgyz Republic. I will consider two Fixed-Effects model models, including the model of the correlation between digital literacy and individual employment, and of the correlation between digital literacy and individual and household income. I will also include such control variables as urban or rural region, nationality, education, age, gender, marital status, and languages which can also influence both employment and income levels.

The thesis contains the following chapters: Introduction, Literature Review, Methodology, Data, Research Analysis, Conclusion and Policy Implications. The introduction presents the research problem, significance and research questions, The literature review provides information about the relevant literature on digital literacy, microeconomic outcomes, and their relationships, with a focus on the Kyrgyz Republic context. The methodology describes the methods and methodological approach used in the study, including data sources, variables, and analytical methods. The research analysis chapter demonstrates the empirical results of the study, including descriptive statistics, regression analysis, and data visualization. The policy

[7] Life in Kyrgyzstan Study. (n.d.). About the LiK Study. Retrieved from https://lifeinkyrgyzstan.org/about-the-lik-study/

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implications section discusses the implications of the findings for policy and practice and directions for future research. The conclusion summarizes the main findings and contributions of the study.

I. Literature Review

Digital development has increased the overall quality of life worldwide for the last several years, but at the same time, some groups of populations, such as rural citizens still do not have access to innovative technologies (Digital National Alliance Bulgaria, 2023). This difference is more significant in developing countries. Digital National Alliance Bulgaria (2023) has suggested that international organizations be active in implementing incentives and policies which can improve the situation and decrease inequality through the improvement of digital literacy among these vulnerable groups[8].

However, to propose effective incentives and policies we should understand the concept of digital literacy and its correlation with microeconomic outcomes.

1.1 Definition of digital literacy.

The concept of digital literacy was presented in 1997 by Paul Glister in his book "Digital Literacy". He considered a digitally literate person as one who can use and understand information in various forms and received from various computer sources (Gilster 1997, p. 1). However, there are also other definitions of the concept which were formed later with the development of technologies.

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[8] Digital National Alliance Bulgaria. 2023. "Digital Literacy: The Great Divide," accessed May 5, 2024, https://www.un.org/techenvoy/sites/www.un.org.techenvoy/files/GDC-submission_Digital-National-Alliance-Bulgaria.pdf

Based on the definition provided by the UNESCO Institute of Statistics Digital Literacy is the general ability of a person to "*access, manage, understand, integrate, communicate, evaluate and create information safely and appropriately through digital technologies for employment, decent jobs and entrepreneurship*" (UNESCO Institute for Statistics 2018). Hall, Nix and Baker (2012) also defined digital literacy as skills required for critical and confident usage of technologies for educational, professional, and communicational issues Considering that the UNESCO Institute for Statistics presents digital literacy as a combination of computer, information, and media literacy, it is also notable to explain these concepts (UNESCO Institute for Statistics 2018).

- ***Computer Literacy.*** The Illinois State Board of Education defines computer literacy as "*an ability to use computers and related technologies efficiently and effectively"* (Illinois State Board of Education 2022).
- ***Information Literacy.*** UNESCO identifies information literacy as the effective evaluation, usage and creation of information which can help reach different aims[9].
- ***Media Literacy*** is the ability and knowledge to use media for critical assessment, securitization, and creation[10].

Microsoft defines Digital Literacy as the ability to use reading, writing, technical skills, and critical thinking for adaptation, living and orientation in the modern world. It includes the usage of smartphones, computers, and other gadgets for searching, processing, evaluating, and sending information[11].

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[9] "Information Literacy | UNESCO," 2023, accessed May 2, 2024, https://www.unesco.org/en/ifap/information-literacy.
[10] "Youth Media Literacy - Federal Chancellery of Austria," accessed May 1, 2024, https://www.bundeskanzleramt.gv.at/en/agenda/youth/youth-media-and-information/youth-media-literacy.html.
[11] "Digital Literacy Courses, Programs & Resources | Microsoft Digital Literacy," Microsoft, accessed May 20, 2024, https://www.microsoft.com/en-us/digital-literacy.

The Digital Competence Framework for Citizens of the European Union (DigComp) does not have a definition of digital literacy but offers a concept of digital competency which is identified as a set of skills and knowledge required for confident, responsible, and critical usage of technologies for work, study, and social interaction (Vuorikari et al. 2022). However, digital literacy is not the only concept which describes the mentioned skills. There are also such concepts as “ICT literacy,” “media literacy,” “digital skills,’ “digital competence,” “technological literacy,” “e-skills” and “information literacy” (Ala-Mutka, 2011).

One of the related concepts mentioned by various authors is Informational and Computer Technology (ICT) skills. DigComp has found a set of specific digital actions needed for each occupation, including agriculture, finance, energy, and migration, however, they found that diverse types of gadgets and occupations need dissimilar digital operations (Vuorikari et al., 2022

According to Lotriet, Matthee and Alexander (2010), the required level of ICT skills might be different for various groups of the population. Thus, one person with the same level of skills can be considered digitally literate in a developing country and illiterate in a developed country due to differences in technologies. However, it can also vary not only on interregional but also on intraregional levels, for example, among rural and urban areas or different occupations (Lotriet, Matthee, & Alexander, 2010).

Luci Pangrazio, Anna-Lena Godhe, and Alejo González López Ledesma (2020) performed a comparative analysis of the concept from various Scandinavian, Spanish and English academic sources and suggested that digital literacy is a complicated concept that changes in different countries due to the given regions' political, social, educational, and technological contexts. They are against the concept's standardization and believe the concept should have a unique

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definition for each country or region based on the local context (Pangrazio, Godhe, and González López Ledesma 2020).

Considering all the mentioned definitions and concepts, we can summarize that digital literacy is the ability to get, process and analyze information received from digital sources and use it in work or education (UNESCO Institute for Statistics 2018). However, there is no one specific and universal definition of this concept (Spante et al. 2018). Moreover, as it was mentioned by Vuorikari (2022) there is no universal set of specific skills and which a digitally literate person should have due to the difference in requirements of specific occupations and countries. In other words, an office manager from Bishkek would not have the same skills as a bank employee in Shanghai even if they both can be considered digitally literate persons. Therefore, I will try to evaluate the level of digital literacy not using a list of specific skills, but as an ability to use digital instruments and computer sources (Gilster 1997) for work or education (UNESCO Institute for Statistics 2018).

1.2 Relationship between digital literacy and economic outcomes.

Based on the definition of digital literacy it can be considered as an ability to use digital technologies for work issues, including entrepreneurship (UNESCO Institute for Statistics 2018).

Jazimatul Husna et al. (2023) investigated the role of digital literacy and a knowledge-based economy for the sustainable development of a 5.0 Society[12]. They used the Care-Based Adoption Model (CBAM) to investigate the factors which can have an impact on young people (Husna et al. 2023). The authors suggest that digitally literate individuals are more successful

[12] Husna, Jazimatul, Liliek Budiastuti Wiratmo, Amir Hussain Ishak, Ghozian Aulia Pradhana, Valentina Farah, and Azzahra Chaerunnissa. 2023. "Digital Literacy and Knowledge-Based Economics: An Analysis of Factors and Contributions for Community Empowerment in Age of Society 5.0." International Journal of Progressive Sciences and Technologies (IJPSAT) 41, no. 2: 427-436.

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in using technologies to achieve economic prosperity and improve the quality of life in society, becoming more digital and technological over time (Husna et al. 2023). For example, people with advanced digital skills will be able to use artificial intelligence and digital services to create positive changes that will improve their living conditions (Husna et al. 2023). The authors believe that digital literacy education will help people be more competitive in an increasingly digital job market, helping them achieve higher incomes (Husna et al. 2023). They consider that such policies will lead to social and economic progress eventually and will create a more inclusive and competitive society (Husna et al. 2023).

Some papers examining the correlation between digital literacy and individual income were conducted in China. For instance, Yuan Yao, Siyu Qin and Yifan Gao (2022) conducted research where they analyzed the impact of digital literacy on the overall income of rural households based on 410 questionnaires in Pucheng County, China The authors used OLS regression to find the correlation between income and digital literacy. They found that digitally literate rural households have higher income, better access to market trends and information and better productivity (Yuan, Qin, and Gao 2022). Authors believe that the implementation and development of projects to improve digital literacy and internet access in rural areas will help to improve the economic situation and quality of life of rural populations (Yuan, Qin, and Gao, 2022).

Another paper written by Bo Liu and Jing Zhou from Shenyang Agricultural University also examined the correlation between digital literacy and income growth using the data from 2018 China Family Panel Studies (CFPS)[13]. They also used the OLS method for their analysis. They found that digital literacy significantly increases individual income and income per capita among rural populations. However, the effect is more significant for people with higher initial

[13] Bo Liu and Jing Zhou. 2023"Digital Literacy, Farmers' Income Increase and Rural Internal Income Gap," Sustainability 15, no. 11: 11422, https://doi.org/10.3390/su151411422.

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income, so it also increases the income gap between high-income and low-income groups in the rural populations (Liu and Zhou, 2023). Therefore, they strongly recommend governments to increase investments in digital literacy and education development and improve digital infrastructure to give access to digital technologies to low-income groups and decrease the income gap (Liu and Zhou 2023).

Zhongwei Chen and his colleagues also examined the impact of digital literacy on individual incomes and the income gap (Liu and Zhou 2023). Similarly, they used the data from 2018 China Family Panel Studies (CFPS) for their research and OLS methodology to conclude that digital literacy significantly increases the individual income and decreases the income gap (Liu and Zhou 2023). Moreover, they found that it leads to a reduction of the income gap between different genders and between urban and rural populations (Liu and Zhou 2023).

Marguerita Lane and Gavan Conlon (2016) analyzed the impact of literacy, numeracy and computer skills on employment and earnings in OECD countries based on 2012 PIAAC data. They found that formally recognized education leads to higher chances to be employed and higher earnings, however, Information and Communication Technologies (ICT) skills can compensate for formally recognized education in the labour market[14]. For example, they found that, on average, people with strong ICT skills and lower levels of formal education are expected to have higher levels of income and employability in comparison with people with low ICT skills and higher levels of formal education (Lane and Conlon 2016). Thus, the authors suggest that ICT skills can fully compensate for the lack of formal education (Lane and Conlon 2016, 3).

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[14] Lane, Marguerita, and Gavan Conlon. 2016. "The Impact of Literacy, Numeracy and Computer Skills on Earnings and Employment Outcomes." OECD Education Working Papers, no. 129. https://dx.doi.org/10.1787/5jm2cv4t4gzs-en.

In 2017 Becker, Pasquini, and Zentner conducted a Digital Literacy Impact Study that examined the role of digital courses in the career outcomes of post-graduate students They concluded that even if universities added digital courses to their curriculum, the students did not get enough practical digital experience (Adams Becker, Pasquini, and Zentner 2017). Therefore, the authors recommend changing digital literacy courses and adding more practical exercises (Adams Becker, Pasquini, and Zentner 2017). It means that the experiments where we have a control and treatment group where the treatment group get digital literacy courses will not be ideal to answer the research questions because the content of the courses could be biased due to different understanding of digital literacy which was mentioned before.

The digitalization gap between urban and rural populations has also been examined by Philip et al. (2017) using the UK as an example. They found that there is a significant digital divide between rural and urban populations and predict that the gap will continue to widen (Philip et al. 2017). Therefore, the authors recommend implementing policies to bridge this gap (Philip et al. 2017).

Regarding the methodology, we can conclude that most of authors used OLS or pooled OLS method for cross-sectional and panel data (Liu and Zhou 2023), (Yuan, Qin, and Gao 2022), (Chen, Wang, and Zhou 2022).

1.3 Digital literacy initiatives.

The development of digital technologies has led to the emergence of various political implications in the digital sphere around the world (Norris 2001). These initiatives have the goal of reducing the digital divide, expanding employment opportunities, and improving overall economic outcomes (Warschauer 2003). Further, we will look at diverse options for developing digital literacy, their goals, and their correlation with microeconomic outcomes (OECD 2016).

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Such initiatives may include educational programs, government policies, and social movements Mossberger et al. 2007).

Education programs most often focus on school education to provide children with digital skills from an early age (Warschauer 2003). However, there are also various educational programs for certain groups of the population, for example, residents of rural areas, women, and the elderly or prisoners (NDLM 2015), (World Bank 2016), (US Department of Education 2024). The second type is community-based activities such as facilitating Internet access or digital literacy workshops. Such events typically target vulnerable groups of the population who have limited access to digital resources and aim to bridge the digital divide (World Bank 2016). The final type of initiative is the introduction of government policies for the development of digital literacy, such as government funding of digital infrastructure, national strategies for the introduction and improvement of digital technologies (NDLM 2015), (World Bank 2016), (US Department of Education 2024).

Previous studies have shown a positive correlation between digital literacy and economic outcomes. Thus, Vuorikari et al. (2022) found that digital literacy initiatives in the European Union had a positive impact on employability and helped reduce unemployment among participants. A World Bank report (2016) claims that digital literacy programs in sub-Saharan Africa have led to increased incomes and improved economic opportunities for people who have completed these programs[15].

In the context of developing countries, digital literacy initiatives have proven particularly effective. Donner et al.'s (2011) study in Kenya found that digital literacy training for small business owners lead to improved business performance and increased revenue (Donner 2011). In India, the National Digital Literacy Mission (NDLM) reported significant improvements in

[15] World Bank. 2016. "Digital Dividends." World Development Report 2016. Washington, DC: World Bank. https://www.worldbank.org/en/publication/wdr2016

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job prospects and income levels among rural populations who received digital literacy training (NDLM 2015).

Prashant Palvia and his colleagues believe that ICT technologies are crucial for developing countries' social and economic outcomes, but also note that citizens' experiences and opinions are important for implementing successful ICT education strategies (Palvia et al.).

1.4 Relevance of digital literacy to microeconomic outcomes in Kyrgyzstan.

The issue of digital literacy is significant for the Kyrgyz Republic not only because of the global trend towards digital literacy, but due to the aim of the country to create a stable economy and come to sustainable growth. Therefore, the vector of digital development is one of the key sections of the National Strategy of the Kyrgyz Republic for sustainable development goals for 2018-2040[16]. As part of this direction, the country has created a nationwide long-term digital transformation strategy "Taza Koom"[17]. Moreover, these efforts in developing digitalization in Kyrgyzstan align with the UN Sustainable Development Goals until 2030. Furthermore, developing digital skills is important to achieving the Millennium Goals (Soltobaev 2020).

According to Soltobaev, people in the Kyrgyz Republic have limited access to personal computers (Soltobaev, 2020). The information from the Statistical Committee of the Kyrgyz Republic confirms this information in Table 1 and Table 2. Only 2.5% of the population had personal computers in 2012 and only 3.7% had personal computers in 2022[18]. Only Bishkek

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[16] Soltoibaev, Aziz, 2020. Digital Skills and Opportunities for Youth Employment towards Digital Economy in the Kyrgyz Republic: UNDP Project -Digital Skills and Entrepreneurship in Kyrgyzstan Expert Report. https://www.undp.org/kyrgyzstan/publications/digital-skills-and-opportunities-youth-employment-towards-digital-economy-kyrgyz-republic

[17] Taza Koom. 2017, June 24. Boosting the Tech Ecosystem of the Kyrgyz Republic.

18 National Statistical Committee of the Kyrgyz Republic (Natsional'nyi statisticheskii komitet Kyrgyzskoi Respubliki). Population Statistics of the Kyrgyz Republic. Resident population as of the beginning of the year. https://www.stat.kg/ru/statistics/naselenie/.

and Osh cities have comparatively high penetration of personal computers 9-12%, while people living in other regions have fewer personal computers.

II. Methodology

I used two models to estimate the correlation of microeconomic outcomes and digital literacy which are described below. Employment and individual income are the microeconomic outcomes that will be considered in the thesis.

Several authors used OLS regression to estimate if there is any correlation between digital literacy and employment or digital literacy and individual income (Liu and Zhou 2023), (Yuan, Qin, and Gao 2022), (Chen, Wang, and Zhou 2022) as it was mentioned in literature review. However, OLS model has limitations, such as unsolved omitted variable bias (Wooldridge 2016). I decided to use the Fixed-Effects (FE) model. It will help to control unobserved factors which do not change over time, but can affect both digital literacy and employment, or both digital literacy and individual income[19]. FE model will provide more accurate results and reduce the risk of omitted variable bias caused by time-invariant variables through isolating the influence of digital literacy and considering only specific individual time-invariant factors (Békés and Kézdi 2021), (Wooldridge 2016), (Dayal and Murugesan 2020).

Individual Employment and Digital Literacy. To estimate the correlation between employment and digital literacy I use the Fixed Effect model, where employment is the dependent variable and digital literacy is an independent variable. The model looks like this:

$$Y_{ij} = \alpha + \beta 1 * DL_{ij} + \beta 2 * X_{ij} + u_{ij} + \varepsilon_{ij},$$

[19] Békés, Gábor, and Gábor Kézdi. 2021. Data Analysis for Business, Economics, and Policy. Cambridge: Cambridge University Press.

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where Y – is the employment dummy, DL is the digital literacy dummy, and X is demographic controls, including education dummy (bachelor's, master's, and PhD), marital status, gender, age, urban/rural status, nationality, and languages.

Individual Income and Digital Literacy. To check the correlation between individual income and digital literacy I use the Fixed effect log-level model, where the natural logarithm of the individual income in Kyrgyz Som (KGS) is the dependent variable and digital literacy is an independent variable. The model is the following:

$$Y_{ij} = \alpha + \beta 1 * DL_{ij} + \beta 2 * X_{ij} + u_{ij} + \varepsilon_{ij},$$

where Y – is ln of individual income in KGS, DL - is Data Literacy, measured as a dummy, X is demographic controls, including education (bachelor's, master's, and PhD), marital status, gender, age, urban/rural status, nationality, and languages.

D*igital literacy* is a dummy variable which is created from the question "How many hours per week do you use a computer for work or study purposes?." It is equal to 1 if a person uses a computer for at least 1 hour per week. This approach considers that a person has basic digital literacy if he or she can use a computer for work or study. However, this approach has limitations which can affect the results of research. First, this approach does not mean that a person has all the required skills to be considered as digitally literate. This limitation can lead to biased results. For example, a person can use a computer for a minimum limited scope of work and does not have enough digital skills to be considered as a competitive player of job market. Additionally, I can have a reverse causality in case if person get a job being digitally illiterate, but further was pushed to learn digital skills to do the job responsibilities.

Moreover, the mentioned criteria will not consider various levels of digital literacy, such as advanced skills in coding or data analysis because we consider only basic level. This fact will

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lead to the issue that the analysis cannot show if the advanced digital skills associated with employment or higher individual income.

Additionally, the thesis relies on the "Life in Kyrgyzstan" survey, which may have certain limitations, lack of data and bias. Also, since the survey was conducted only on the territory of the Kyrgyz Republic, the results may be influenced by country-specific factors in Kyrgyzstan, which may be irrelevant for other regions and countries.

The impact of the limitations can be significant for the analysis because it can lead to biased results. To mitigate the limitations, we can use more complex methods to evaluate digital literacy in further analyses in future. For instance, researchers can add specific tests to evaluate and group the level of digital literacy or add supplementary questions to the existing survey to evaluate digital literacy more effectively. Additionally, they can try to make specific experiments with treatment and control groups to make an impact evaluation. Considering all the mentioned limitations we should accurately interpret the results and consider that it can lead to bias in the results.

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III. Data

2.1 Overview

For my thesis, I will use data from the Life in Kyrgyzstan (LiK) database. In 2010-2012, the study was conducted with financial support from the German Volkswagen Foundation. Further stages of the project were carried out with the support of organizations such as the German Institute for Economic Research (DIW Berlin) as the consortium leader, Stockholm International Peace Research Institute (SIPRI) as the lead institution, the University of Central Asia (UCA) as the main Kyrgyz partner, as well as DFID, IZA, UN- FAO, IFPRI. The data collection for the LiK study was conducted by Sotseconik and SIAR Consult research companies.

This survey used a stratified two-stage random sampling method to collect information from approximately 8,000 individuals and 3,000 households. The LiK database includes representation from all seven regions (regions) of Kyrgyzstan, as well as the cities of Bishkek and Osh, which allows for a representative sample at both the national and regional levels.

Data collection was conducted annually from 2010 to 2013, and in 2016 and 2019. Each wave was conducted around October–November, although slight variations in fieldwork dates occurred due to national elections and other factors. The longitudinal nature of the LiK study allows data to be collected from the same 3,000 households and over 8,000 individuals, making it possible to track trends and changes in the lives of households and specific individuals.

This survey contains the most diverse set of households due to a special sampling strategy based on 2009 census data and developed in collaboration with the National Statistical Committee (NSC) of the Kyrgyz Republic. Household attrition rates are low; for example, in the second wave, 90.2% of individuals and 95.2% of households were reinterviewed.

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LiK classifies Households as persons who share one living place or household arrangements, both related and unrelated to each other. Family members living away from their households, such as migrants or students, are treated as absent household members and are not included in individual surveys until they return to the household territory and resume cohabitation.

LiK includes a massive range of socio-economic characteristics, including subjective well-being, income, health, education, employment, consumption, and migration. The dataset is particularly valuable for researchers studying transition economies, as longitudinal research projects in the post-Soviet region are few.

Key Variables

Digital Literacy. As was mentioned in the literature review, digital literacy can be identified as the ability to use, get and analyze information from digital sources for work and study. Therefore, to identify digital literacy, I used the answer to the question "How many hours per week do you use a computer for work or study purposes?" I created a new dummy variable "digital literacy" which is equal to 0 when a person does not use a computer and 1 in case if a person uses a computer for at least 1 hour per week. I consider that a person can use a computer for work or study purposes only in thecase if he or she has basic digital literacy skills. This method of evaluation for digital literacy can have limitations which I will discuss in detail in the Methodology section, but it can efficiently demonstrate the picture of basic digital literacy of respondents.

Employment. It is a dummy variable which is equal to 1 when a person has been either working for any organization, household, or farm, or being an entrepreneur for the last 7 days before the annual interview according to the logic of the survey.

ln_income. I used the natural logarithm of Income, which is the sum of income from all main and additional places of employment calculated in KGS. Some respondents also get income in

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USD, for them I calculated the average annual exchange rate for the KGS/USD currency pair based on the daily statistics of the National Bank of the Kyrgyz Republic (NBKR)[20]. It was 45.9884 KGS/USD in 2010, 46.1359 KGS/USD in 2011, 47.005 KGS/USD in 2012, 48.4386 KGS/USD in 2013. For 2016 and 2019 LIK provided income data only in KGS.

Control Variables

Age. The variable indicates the age of respondents and restricted to individuals to focus on the working-age population with higher digital literacy. I deleted all data for individuals below 18 because it is the age of majority in the Kyrgyz Republic[21] and people above 50 because they were born before digitalization and have lower digital literacy than young people (Anderson & Perrin, 2017), (Friemel, 2016).

Female. It is a dummy variable indicating females.

Literate. This is a dummy variable showing if a person can easily read and write.

Kyrgyz, Russian, English. These are dummy variables which showing if people know Kyrgyz, Russian and English. Currently Kyrgyz is the national language of the Kyrgyz Republic, and Russian is the official language. English can be considered as the most popular business language.

Oblast_Bishkek_City and Oblast_Osh_City. The dummy variables for Bishkek and Osh cities which can be considered as urban regions as capital and second biggest city in the Kyrgyz Republic.

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[20] National Bank of the Kyrgyz Republic. "Official Exchange Rates." Accessed May 28, 2024. https://www.nbkr.kg/index1.jsp?item=1562&lang=ENG.

[21] Government of the Kyrgyz Republic. "Resolution No. 3 of January 24, 2005." (Pravitel'stvo Kyrgyzskoi Respubliki. "Postanovlenie ot 24 yanvarya 2005 goda № 3."). Accessed May 28, 2024. https://cbd.minjust.gov.kg/56111/edition/1154296/ru.

Nationality. These are dummy variables identifying various nationalities. I took Kyrgyz, Kazakh, Russian, Uzbek, Tajik, Uigur, and Dungan as separate dummy variables.

Education_university. It indicates if an individual has a university-level degree (bachelor, master, PhD).

2.2 Descriptive Statistics

There are 38,353 observations and 10,975 unique individuals in my sample which includes 2010, 2011, 2012, 2013, 2016 and 2019 years. The panel dataset is unbalanced because some respondents did not participate in some specific years and some respondents matured or reached the age of 51 during the period of the survey. We can see the summary of the descriptive statistics of categorical variables in Table 3, Picture 1, and Picture 2 below:

Table 3. Summary descriptive statistics for categorical variables

Name	0		1	
	number	%	number	%
digital literacy	29 234	76%	9 119	24%
employment	20 850	54%	17 503	46%
literate	4 744	12%	33 609	88%
kyrgyz_language	12 470	33%	25 883	67%
russian_language	14 885	39%	23 468	61%
english_language	37 103	97%	1 250	3%
female	18 983	49%	19 370	51%
marital_status_married	14 285	37%	24 068	63%
education_university (bachelor, master, PhD)	32 931	86%	5 422	14%
oblast_Bishkek_City	33 253	87%	5 100	13%
oblast_Osh_City	36 361	95%	1 992	5%
nationality_Dungan	37 044	97%	1 309	3%
nationality_Kazakh	38 200	100%	153	0%
nationality_Kyrgyz	11 473	30%	26 880	70%
nationality_Russian	36 224	94%	2 129	6%
nationality_Tajik	37 990	99%	363	1%
nationality_Uigur	37 658	98%	695	2%
nationality_Uzbek	32 547	85%	5 806	15%

Picture 1. Binary Distribution Plots for categorical variables (part 1)

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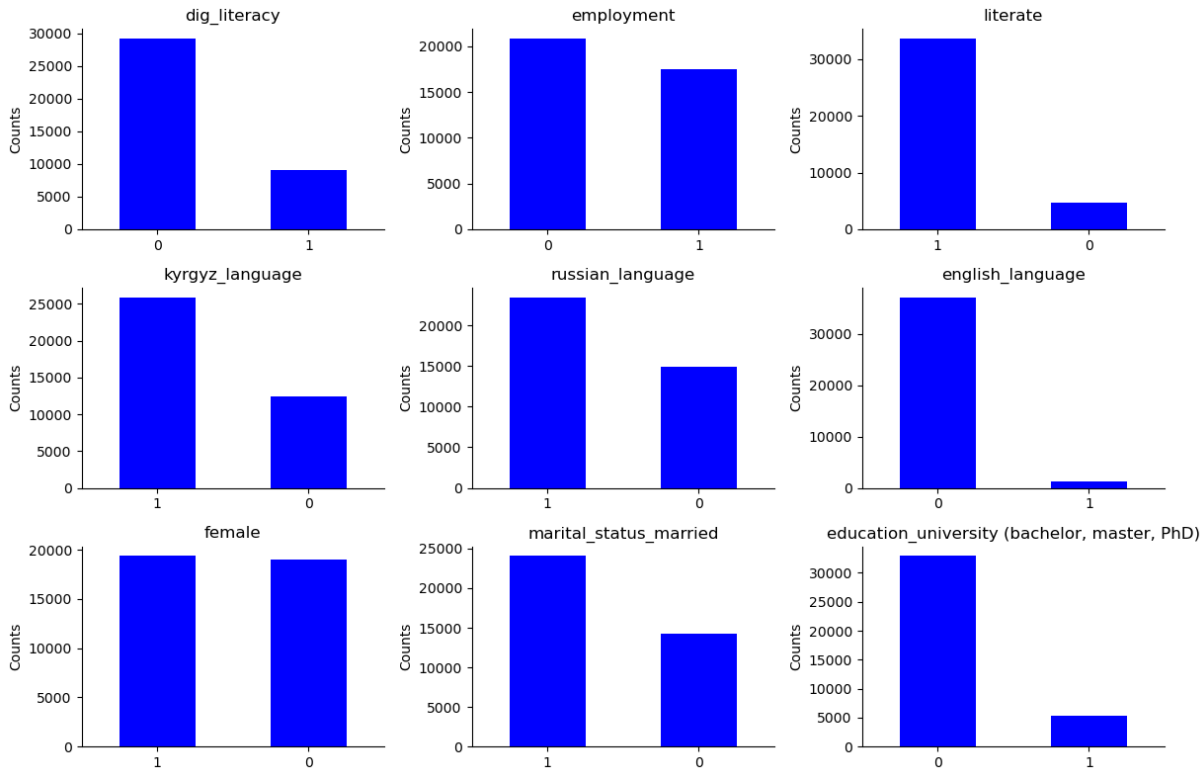

Picture 1 shows the first part of categorical variables, such as digital literacy, employment, literate, knowledge of languages, gender distribution, marital status_married, education_university (bachelor, masters, PhD).

We can see that 76% of respondents are not digitally literate, so they do not use computers at all, and 24% are digitally literate, so a significant part of population does not have even basic level of digital literacy. The employment dummy is more balanced 54% are unemployed and 46% employed. As for general literacy, 88% of the database are literate. Gender distribution is comparatively balanced with 51% of female and 49% male population. The database includes more married people (63%) than single ones (37%). Education is unbalanced, most of the population (86%) does not have a university degree. As for the languages, we can see that most of the population speaks Kyrgyz and Russian languages which are national and official languages, while English is not so popular. However, I will leave English because it the most global language and can be associated with higher employment rates and earnings.

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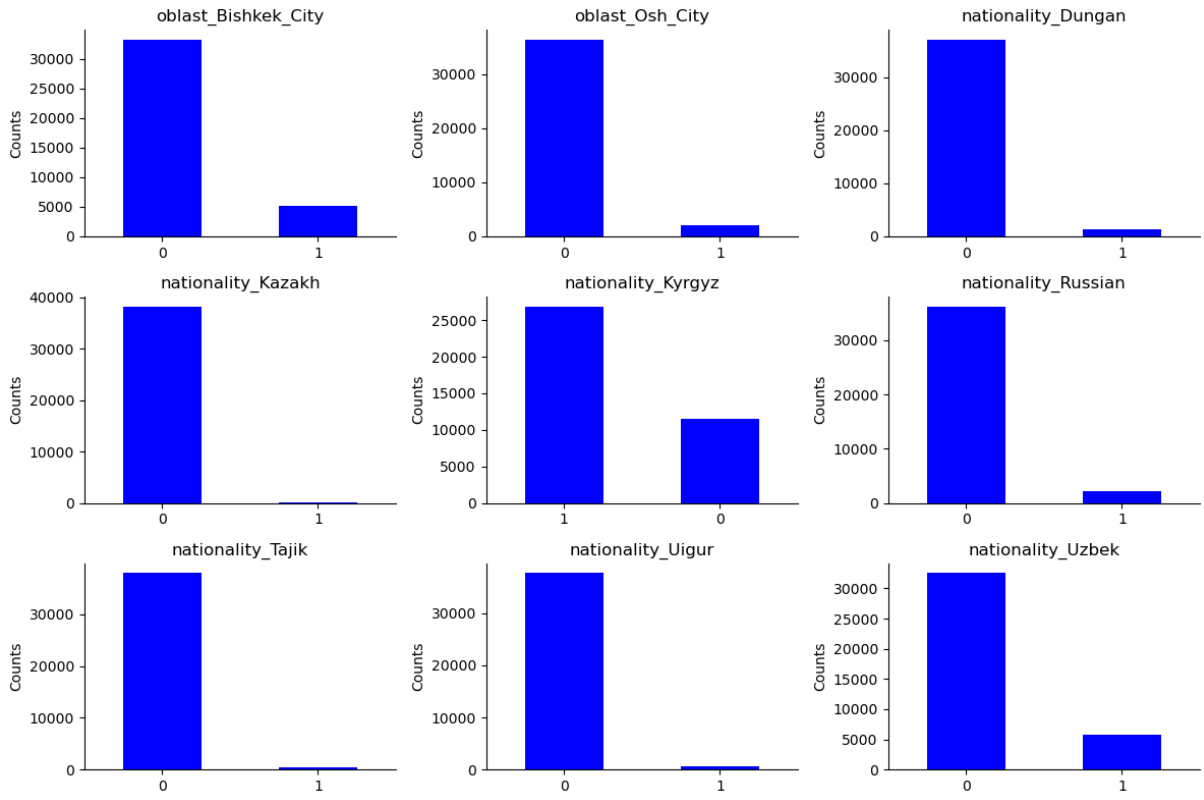
Picture 2. Binary Distribution Plots for categorical variables (part 2)



Picture 2 shows the first part of categorical variables, such as nationality and regional distribution.

We can see that only 13% of respondents live in the capital, and only 5% in Osh city, which means that most of the Kyrgyz population lives in rural areas. Taking in account the previous discussion of digital and income gap between of urban and rural populations in literature review (Philip et al. 2017), (Liu and Zhou 2023), this can lead to the case that the digital literacy or income is associated with living in urban areas. However, I will not merge these variables because the level of urbanization of Bishkek and Osh city can be different. As for nationality distribution, Kyrgyz people have the biggest share of the population in Kyrgyzstan (70%), then Uzbek people with 15% of share and then Russian people, while other nationalities can be considered as national minorities. Therefore, I will leave only three nationalities with the biggest share for the regression analysis.

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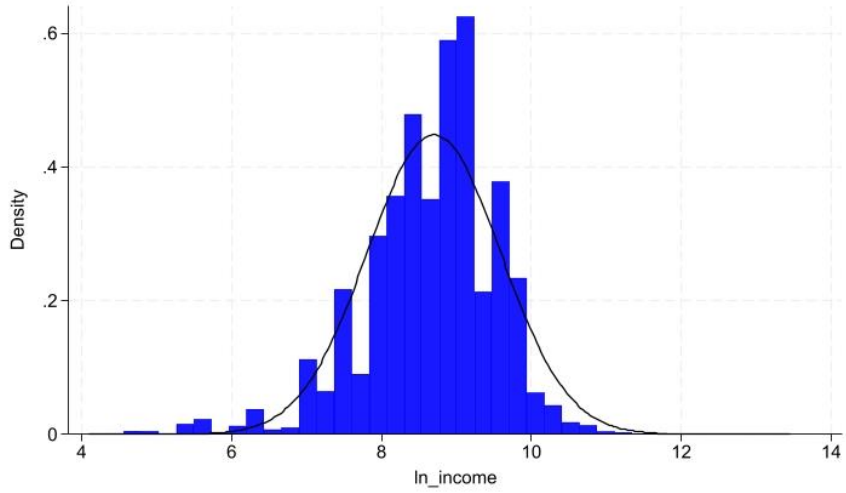
Picture 3. Distribution of Age

Picture 3 shows that the histogram of age is skewed to the right which means that there are more younger people in the dataset from 18 to 30 than people over 35.

Graph 1. Histogram of ln_income



The histogram of the natural logarithm of income shows that we have a normal distribution of ln_income, so we have a lognormal distribution of income (Wooldridge, 2016) and data which are closer to the mean are more frequent in comparison with other data (Békés and Kézdi 2021). The natural logarithm of income lies between 4 and 14.

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IV. Empirical Results

4.2 Employment

Table 4 shows the result of the regressions where employment is the dependent variable and digital literacy is the independent variable. As I mentioned in Methodology, I used Fixed-Effects model where I fixed all time invariant factors.

Table 4. Individual Employment and Digital Literacy: Fixed-Effects Model

Variables	Fixed-Effects Model
dig_literacy	0.04 ***
	(0.01)
age	0.01 ***
	(0.00)
female	-0.21 ***
	(0.00)
marital_status_married	0.04 ***
	(0.01)
literate	0.19 ***
	(0.01)
university_degree	0.15 ***
	(0.01)
kyrgyz_language	0.11 ***
	(0.01)
russian_language	0.10 ***
	(0.01)
english_language	-0.03 *
	(0.01)
oblast_Bishkek_City	0.06 ***
	(0.01)
oblast_Osh_City	0.02
	(0.01)
nationality_Kyrgyz	-0.03 ***
	(0.01)
nationality_Russian	0.14 ***
	(0.01)
nationality_Uzbek	-0.06 ***
	(0.01)
R^2	***0.20***
Adj. R^2	***0.20***
Num. obs.	***38 353***
****** p <0.001; ** p <0.01; * p <0.05***	

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In Fixed Effect Model R -squared shows that the model explains about 20% of variability of dependent variable. It is the highest R-squared among seven models I ran with graduate adding of variables (Table 5, Appendices) The coefficient for digital literacy is statistically significant on all levels ($p < 0.001$) for all models. It means the basic digital literacy is associated with a 0.04 unit increase in employment variability. Other highly significant coefficients ($p < 0.001$) are age, gender, marital status, general literacy, university degree, knowledge of Kyrgyz and Russian languages, living in Bishkek City and nationality. Coefficient of English language is significant only on 95% confidence level ($p < 0.05$). Other variables are not significant. It is also interesting that being female, Kyrgyz or Uzbek is associated with lower employment rates, while being digitally literate, married, older, literate university graduate with knowledge of Kyrgyz or Russian is associated with higher employment possibility. Gender, university degree and literacy have the highest absolute values of coefficient which means that they are highly correlated with employment.

4.3 Individual Income

Table 6 shows the result of the Fixed-Effects model where the natural logarithm of income is the dependent variable and digital literacy is the independent variable. This is a log-level model. The R-squared means that the given model can explain about 14% variability of dependent variable. It is the highest R-squared among seven models I ran with graduate adding of variables (Table 7, Appendices) The coefficient for digital literacy is statistically significant on all levels ($p < 0.001$) for all models. It means the basic digital literacy in average is associated with 17% increase in individual income variability. Other highly significant coefficients ($p < 0.001$) for ln-income are age, gender, marital status, university degree, knowledge of Russian language, living in Bishkek or Osh cities and Kyrgyz or Uzbek nationalities. Coefficient of English language and Russian nationality are significant only on

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99% confidence level ($p < 0.01$). Knowledge of Kyrgyz language and literacy are not significant. It is also interesting that being female, Kyrgyz, Russian or Uzbek is associated with lower individual income rates, while being digitally literate, married, older, university graduate living in Bishkek or Osh cities with knowledge of Russian or English languages is associated with higher income. Gender, university degree, Russian language and living in Bishkek or Osh cities and Kyrgyz or Uzbek nationalities have the highest absolute values of coefficient which means that they are highly correlated with individual income.

Table 6. Individual Income and Digital Literacy: Fixed-Effects Model

Variables	**Fixed-Effects Model**
dig_literacy	0.17 ***
	(0.02)
age	0.01 ***
	(0.00)
female	-0.29 ***
	(0.02)
marital_status_married	0.07 ***
	(0.02)
literate	-0.03
	(0.03)
university_degree	0.20 ***
	(0.02)
kyrgyz_language	-0.00
	(0.03)
russian_language	0.16 ***
	(0.02)
english_language	0.10 **
	(0.04)
oblast_Bishkek_City	0.40 ***
	(0.02)
oblast_Osh_City	0.35 ***
	(0.03)
nationality_Kyrgyz	-0.27 ***
	(0.03)
nationality_Russian	-0.11 **
	(0.04)
nationality_Uzbek	-0.29 ***
	(0.04)
R^2	**0.14**
Adj. R^2	**0.14**
Num. obs.	**10 465**
****** p <0.001; ** p <0.01; * p <0.05***	

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One issue which can occur in the given models is the endogeneity problem or existence of endogenous unobserved explanatory variable which can affect both digital literacy and employment or digital literacy and individual income (Wooldridge, 2016). At the same time, we can see the reverse causality problem (Békés and Kézdi 2021), (Dayal and Murugesan 2020) in case employed people with high individual income start learning digital skills to be competitive in career. To avoid the problem, we can try usage of instrumental variable analysis, difference-in-differences estimation, or propensity score matching in further research (Békés and Kézdi 2021), (Dayal and Murugesan 2020).

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Conclusion

The research makes a significant input into understanding digital literacy in the Kyrgyz Republic. It concludes that basic digital literacy is positively correlated with higher employment rates and individual income in Kyrgyzstan. For this analysis, I used Life in Kyrgyzstan panel survey for six years including 2010-2013, 2016 and 2019 years, I ran a Fixed-Effect model with controlling time-invariant factors to avoid omitted-variable-biased which can be an issue in OLS regression which previous researchers used for this topic. The positive correlation confirms the theories in the literature review about the positive correlation of digital literacy with both employment and individual income. This correlation confirms the previous findings mentioned in the literature review and show the importance of implementing digital literacy programs in the Kyrgyz Republic.

At the same time, it is important to remember all limitations of the study, such as endogeneity and potential reverse causality. Additionally, the chosen method of digital literacy evaluation limits the study only to a basic level of literacy which does not allow us to separate advanced and basic skills which can also be associated with dependent variables.

It is also important to note limitations of the Life in Kyrgyzstan study, such as potential data gaps and bias. There is also the possibility of country-specific factors influencing the ability to interpret results for other countries. Therefore, due to these limitations, the results of the study must be interpreted with caution.

Future research could consider other digital literacy assessment methodologies to overcome these limitations. For example, the introduction of practical tests to assess the level of digital literacy will help to obtain the real level of digital literacy of respondents, and not a subjective assessment. Another example of obtaining better data would be to introduce additional questions into the LIC questionnaire specifically to determine the level of digital literacy. Also,

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an excellent research option could be a social experiment with a division into control and treatment groups, where one group will be taught digital literacy courses, and in the future the dynamics of employment will be examined.

Instrumental variables can also be introduced to avoid the endogeneity problem. In this way, the reliability of the study results can be increased.

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Policy Implications

Even though we found only a positive correlation between digital literacy and employment, digital literacy and individual income, the studies in literature review suggests that the trainings in digital literacy can lead to higher employment and income rates (Donner 2011). Therefore I can suggest the following policy implications:

Educational Programs. The government can implement specific educational programs to enhance digital literacy among population the same as it was implemented in India (NDLM 2015), Sub-Saharan Africa (World Bank 2016), USA (US Department of Education 2024) and Europe (European Commission 2016). The program for rural populations as it was implemented in India would be especially useful taking in account that majority of the population in the Kyrgyz Republic lives in rural areas. Additionally, taking in account the positive correlation between employment and digital literacy and negative correlation between employment and being a woman, I would suggest implementing specific digital literacy courses for women. Moreover, adding digital literacy courses to school programs can help to extend digital literacy among the young generation.

Digital Infrastructure. Learning digital skills cannot be efficient if there is limited access to digital infrastructure, such as internet connection, telecommunication, and electricity. Therefore, it is important to invest in digital infrastructure too because otherwise even digitally literate people will not be able to use their skills.

Supporting digital entrepreneurship. Supporting entrepreneurs who promote digital technologies, startups and communications can help to improve the level of digital literacy because these entrepreneurs will develop digitalization in the framework of their business.

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Supporting Fintech Technologies. Supporting Fintech technologies can help not only to improve the digital literacy of community in natural way, but also help rural population to enter market as SME.

S*upporting Educational Institutions (Schools, Universities) With Digital Majors*. There are several technical universities, colleges, and schools with a mathematical or digital focus in the Kyrgyz Republic. Supporting them financially and implementing joint initiatives will help to teach digital skills faster and get prepared methodologies of teaching.

International Collaboration. Collaboration with digitally oriented countries and international organizations can help to get the best international practices for enhancing digital literacy.

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Appendices

Table 1. Number of Personal Computers in the Kyrgyz Republic (thousands of units)[22]

Year / Oblast	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Kyrgyz Republic	**137**	**154**	**167**	**175**	**178**	**190**	**203**	**222**	**223**	**247**	**255**
Batken	5	6	6	7	7	7	8	9	10	11	11
Jalal-Abad	9	13	14	15	16	17	18	20	21	22	23
Issyk-Kul	8	8	10	10	10	10	11	11	11	12	13
Naryn	5	6	6	6	7	7	8	8	8	9	10
Osh	7	7	9	10	10	11	13	14	15	16	17
Talas	4	5	5	5	5	5	6	6	6	6	8
Chui	11	14	15	14	15	16	17	20	20	21	22
Bishkek City	78	83	90	95	95	100	107	115	115	132	131
Osh City	10	11	12	13	14	15	16	17	18	19	20

Table 2. Resident population (thousands of people)[23]

Items	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Kyrgyz Republic	**5 552**	**5 663**	**5 777**	**5 895**	**6 019**	**6 140**	**6 256**	**6 390**	**6 524**	**6 637**	**6 913**
Batken	449	459	470	481	493	504	514	525	537	548	560
Jalal-Abad	1 054	1 077	1 099	1 122	1 147	1169	1 191	1 214	1 239	1 261	1 288
Issyk-Kul	448	453	459	464	470	477	483	490	496	502	534
Naryn	265	268	271	275	278	281	284	287	290	292	307
Osh	1 148	1 173	1 200	1 228	1 260	1288	1 314	1 342	1 368	1 392	1 436
Talas	235	240	243	247	251	255	259	264	267	271	270
Chui	823	838	854	870	889	905	922	941	960	975	1 055
Bishkek City	874	895	916	937	959	980	1 002	1 027	1 054	1 074	1 114

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Osh City	256	260	265	270	270	282	289	300	312	322	351

Table 5. Individual Employment and Digital Literacy: Fixed-effects Models

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
dig_literacy	0.11 ***	0.16 ***	0.17 ***	0.08 ***	0.06 ***	0.05 ***	0.04 ***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
age		0.02 ***	0.01 ***	0.01 ***	0.01 ***	0.01 ***	0.01 ***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
female		-0.20 ***	-0.20 ***	-0.21 ***	-0.21 ***	-0.21 ***	-0.21 ***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
marital_status_married			0.05 ***	0.03 ***	0.03 ***	0.03 ***	0.04 ***
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
literate				0.22 ***	0.20 ***	0.20 ***	0.19 ***
				(0.01)	(0.01)	(0.01)	(0.01)
university_degree				0.18 ***	0.17 ***	0.15 ***	0.15 ***
				(0.01)	(0.01)	(0.01)	(0.01)
kyrgyz_language					0.06 ***	0.07 ***	0.11 ***
					(0.01)	(0.01)	(0.01)
russian_language					0.13 ***	0.12 ***	0.10 ***
					(0.01)	(0.01)	(0.01)
english_language					0.01	-0.02	-0.03 *
					(0.01)	(0.01)	(0.01)
oblast_Bishkek_City						0.08 ***	0.06 ***
						(0.01)	(0.01)
oblast_Osh_City						-0.00	0.02
						(0.01)	(0.01)
nationality_Kyrgyz							-0.03 ***
							(0.01)
nationality_Russian							0.14 ***
							(0.01)
nationality_Uzbek							-0.06 ***
							(0.01)
R^2	0.01	0.14	0.14	0.17	0.19	0.19	0.20
Adj. R^2	0.01	0.14	0.14	0.17	0.19	0.19	0.20
Num. obs.	38353	38353	38353	38353	38353	38353	38353

*** p < 0.001; ** p < 0.01; * p < 0.05

Table 7. Individual Income and Digital Literacy: Fixed-Effect Log-Level Models

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
dig_literacy	0.32 ***	0.38 ***	0.38 ***	0.26 ***	0.21 ***	0.18 ***	0.17 ***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
age		0.01 ***	0.01 ***	0.01 ***	0.01 ***	0.01 ***	0.01 ***
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
female		-0.26 ***	-0.26 ***	-0.28 ***	-0.28 ***	-0.29 ***	-0.29 ***
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
marital_status_married			0.02	0.01	0.04	0.07 ***	0.07 ***
			(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
literate				-0.01	-0.01	-0.03	-0.03
				(0.03)	(0.03)	(0.03)	(0.03)
university_degree				0.31 ***	0.28 ***	0.20 ***	0.20 ***
				(0.02)	(0.02)	(0.02)	(0.02)
kyrgyz_language					-0.20 ***	-0.14 ***	-0.00
					(0.02)	(0.02)	(0.03)
russian_language					0.23 ***	0.18 ***	0.16 ***
					(0.02)	(0.02)	(0.02)
english_language					0.20 ***	0.10 **	0.10 **
					(0.04)	(0.04)	(0.04)
oblast_Bishkek_City						0.40 ***	0.40 ***
						(0.02)	(0.02)
oblast_Osh_City						0.31 ***	0.35 ***
						(0.03)	(0.03)
nationality_Kyrgyz							-0.27 ***
							(0.03)
nationality_Russian							-0.11 **
							(0.04)
nationality_Uzbek							-0.29 ***
							(0.04)
R^2	0.03	0.06	0.06	0.08	0.10	0.13	0.14
Adj. R^2	0.03	0.06	0.06	0.08	0.10	0.13	0.14
Num. obs.	10465	10465	10465	10465	10465	10465	10465

*** p < 0.001; ** p < 0.01; * p < 0.05

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