Potential Pitfalls of Data Fusion Digitalization in Microfinance Context

Maxbuba Ismailova[*1], Nargiza Alimukhamedova[2]

[1] Department of Financial Analysis and Audit, Tashkent State University of Economics, Uzbekistan
[2] Westminster International University in Tashkent, Uzbekistan
[2] Prague University of Economics and Business (VŠE), Czechia
Emails: m.ismoilova@tsue.uz; nalimukhamedova@wiut.uz

Abstract

The current era of socio-economic development is featured by rapidly increasing fusion of technology and rapid data fusion digitalization of human activities. While most of these advancements are promising to bring various positive aspects, such as reductions in cost and time, there are potential pitfalls that should be considered. In this paper, we aim to measure potential challenges that data fusion data fusion digitalization could bring in the microfinance context. First, we provide the set of stylized facts and trends in data fusion digitalization using three measures: mobile cell users, internet provision, and mobile-money-service provision. The trends in data fusion digitalization are provided across groups of countries by different income levels. Secondly, using pair-wise correlations we analyze how the set of five microfinance financial and five social indicators are correlated with the digital ranking of countries. Our results demonstrate that while there are increasing patterns in data fusion digitalization in most of the developing countries, negative correlations are observed. We explain the negative implications of data fusion digitalization due to increasing moral hazard and asymmetric information. Our findings call for further research on the long-term implications of digitalization in other areas of social sciences so that to better cope with potential challenges.

Keywords: microfinance; data fusion; digitalization; moral hazard; asymmetric information

1. Introduction and motivation

The past decade and particularly post-Covid 19 pandemic times revealed ever-increasing dominance of technology, data fusion digitalization, and artificial intelligence. Being under the lock-down for long months, households and firms had to rely on working at the distance where remote technologies such as Zoom, cloud technologies, and mobile technologies. Most the human services such as access to banks and credits, teaching and education processes, and services have been shifted towards distance mode. The time showed that most of the routine human activities and job places could be replaced with machines, technologies, and artificial intelligence. Data fusion digitalization as it called in the common term, is currently perceived as the most promising way of organization work process, and public service provision and even included to United Nation's 16 SDG (Social Development Goals).

It is undoubtful that digitization is aimed to bring many positive aspects such as reductions in cost, time, operational cost, and better management for both clients and providers. At the same time, there could be potential pitfalls and hidden challenges that the overuse of technologies and data fusion digitalization could bring to society. The primary reasoning behind these challenges is that in certain areas that are associated with human contact, such as medical treatment, and taking loan from the bank, data fusion digitalization assumes very limited or almost none of interaction with humans. As a result, information asymmetries such as moral hazard [1] and asymmetric information [2].

Doi: https://doi.org/10.54216/FPA.120208
Received: January 25, 2023 Revised: April 24, 2023 Accepted: June 22, 2023

In this paper, we aim to shed light on trends in data fusion digitalization across countries with different income groups and provide evidence of potential pitfalls from microfinance context. We use three prominent measures of data fusion digitalization which also demonstrate fusion technologies in practice. These measures include mobile users, internet users, and mobile-money-service provision. Next, we provide a set of pair-wise correlations of digitalization with microfinance indicators. We choose five financial indicators of microfinance such as (1) average assets (2) average gross loan portfolio (3) financial revenue (4) gross loan portfolio (5) operative expenses. We also use five social indicators of microfinance including (6) average loan balance per borrower (7) average number of active borrowers (8) number of active borrowers (9) number of active borrowers (10) percent of female borrowers (%).

Since its first introduction in 1970, microfinance has become a popular development policy offering small-sized financial services to the less advantaged. The microfinance sector experienced phenomenal growth in the early 21st century, expanding to most developing countries. Much of its success is attributed to innovative operating procedures and contracting practices that have proven effective in the context of severe uncertainty and information asymmetries due to borrower opacity and institutional void [3] [4]. Microfinance institutions (MFIs) enter into contracts with outside investors. Motivated either by for-profit or social motives, investors supply their funds and support the small entrepreneurship projects. Because MFIs tend to operate in an environment without efficient institutions to enforce financial contracts and without credible information about the prospective solvency of their clients, they have developed innovative contractual arrangements to deal with the problems of asymmetric information, notably featuring joint-liability, dynamic incentives and leveraging on social collateral [5].

To the best of our knowledge, the state of digitalization in microfinance has yet to be reviewed considering the hidden pitfalls of digitalization [6]. While literature reviews of financial technologies have been attempted, studies on digital microcredit are especially thin due to the lack of reliable data. The need for such a review has become even more important in the context of the recent Covid-19 pandemic, during which human interactions were significantly reduced in countries around the world. Indeed, the microfinance landscape has been affected in many countries too, which calls for more extensive use of digital technology for conducting business [7].

Our main findings suggest that while there are numerous benefits from digitalization, fusion of digital technologies in the context of microfinance there may be potential hidden impediments such as adverse selection and moral hazard. Microfinance programs have been popular precisely because of the face-to-face, personalized approach to clients that reduced asymmetric information issues. We demonstrate that with rapidly increasing digitalization, the sustainability, social, and financial performance of microfinance programs could be hindered. Overall results indicate that more research on potential challenges of digitalization should be conducted, so that to better prepare as opposed to coping with aftermath consequences.

The rest of our paper is structured as follows. Section 2 provides a review of related studies. Section 3 describes the methodology and data used. Section 4 presents the results. The last section concludes.

2. Literature review

Literature related to our study could be classified to the following main stands. The first group relates to studies analysing digitalization, technological advancements and fusion of technologies. Second stream focuses on digitalization in microfinance context.

The negative and positive impact of digital microcredit are brought to the attention by [8] in rural areas. From the savings perspective, mobile money can increase the rate of returns and prevent households from excessive spending. From the borrower's perspective, it is costly for lenders to collect information about borrowers' responsibility, while joint-liability microfinance institutions obtain more plausible information about borrowers and this information is less costly for them. In study [9] author suggests adopting digital finance to improve rural Malaysian micro enterprises' productivity. The growing use of technology for aiding human services such as face recognition is analysed in [10].

Digitalization can potentially aggravate moral hazard and adverse selection problems, which are the key drivers of credit default risks due to severe informational asymmetries between lenders and borrowers of microcredit. We

Doi: https://doi.org/10.54216/FPA.120208
Received: January 25, 2023 Revised: April 24, 2023 Accepted: June 22, 2023

find that digitalization can have both positive as well as negative effects. For instance, digital technologies allow MFIs to cut costs and speed up processing while hurting relationship building and local presence. For clients, digital microcredit means easier and wider access but leads to overextension, e.g. over-borrowing due to psychological biases and bounded rationality. This means that the research community should focus on understanding the causal mechanisms of these effects to help design better products in the future.

In study by [11] authors provide a unique view of integrating digital solutions into MFIs. In particular, they discuss a link between the social missions of MFIs' promotions of digital financial services. In addition, the practical application of efficient integration can be useful for policymakers and financial institutional regulations. [12] use a case of mobile money applications in Indonesia to show the growth of financial inclusion and, as a result, social efficiency in particular MFIs. According to [13], digital transformation allows MFIs to enhance their capacity and to be adjusted to innovation processes. In recent study of [14] authors present fusion analysis and blog feedback predictions using machine learning model.

Discussing the role of information technologies in microfinance, [15] mention that Information and Communication Technology helps MFI to be stable in a competitive environment and extend services to different population segments. In study by [16] authors argues that digitalization may improve loan repayment functionality in MFIs in Malaysia using mobile banking. In study [17] authors provide a digital solution that might enable low-literate clients to use digital technologies. Using new Machine Learning algorithms may improve the accuracy of forecasting credit eligibility and the use of a robust credit scoring model. Blockchain technology is aimed to eliminate problems with information insecurity and fraud and will allow microfinance to thrive in the future. In study by [18] authors stipulate that no studies exist on the negative effects of digital credits. Moreover, [19] argue that digitalization leads to the socio-economic transformation of society. There are studies devoted to experiencing from emerging countries regarding technical issues, benefits for the poor, and economic consequences – especially for economic growth – and the implementation of digital financial services, These findings are documented in studies of [20] [21] [22] [23] [24] [25].

In his research [26] argues that digitalization is aimed to be pro-poor and pro-development despite the fact that it connects with fraud and infrastructure risks. Reviewing African experience in use of mobile technologies [27] find that mobile money can affect the economy through financial inclusion. The rapidly developing mobile financial market helps the government to increase budget revenue by taxing mobile money transactions in Africa. [28] emphasizes that, despite the high level of development of digitalization, there are few products from European microfinance institutions for the poor. Interestingly, according to [29], the low spread of fintech solutions in Europe can be explained by the reluctance of MFIs to lose personal communication with clients. This fact is in line with findings of [30], who emphasize that digitalization may damage the personal relationship between client and provider, which is a key advantage of microfinance.

We've counted more than 108 studies that analyse various aspects of digitalization in the microfinance context. Compared to these studies, our novel contribution could be defined as follows. First, we provide a trend analysis of digitalization differs across various countries as measured by income and development. The set of stylized facts that we provide is very important to understand which group of countries will potentially fall under the risk of digitalization that we bring to the attention. Second, we measure and provide set of pair-wise correlations of digitalization with microfinance indicators such as financial and social indicators.

3. Research question and objectives

Inspired by the recent trends in digitalization our primary research question is formulated as follows:
Main research questions: *What are cross-country differences in digitalization? What are potential pitfalls of digitalization in case of microfinance ?*

In support of the main research question, we also formulate a set of the following research objectives:

Research objective 1: To determine trends in different measures of digitalization
Research objective 2: To determine how digitalization differs by income group of countries
Research objective 3: To measure how digitalization and microfinance financial indicators are correlated?
Research objective 4: To measure how digitalization and microfinance social indicators are correlated?

Doi: https://doi.org/10.54216/FPA.120208
Received: January 25, 2023 Revised: April 24, 2023 Accepted: June 22, 2023

4. Methodology

Given that our main research question is to uncover cross-country differences in digitalization, our primary methodology is based on *quantitative analysis.*

More specifically, we've used the following types of quantitative analysis:

(i) Trend Analysis
(ii) Rank Analysis
(iii) Pair-wise Correlations

To measure the strength of relationships between variables we focus on Pearson's Correlation Coefficient which was first developed by [32]. The correlation coefficient is based on well-known formulas which usually are presented in different sources. For instance, [34] uses the following equation to describe the relationship between two random variables:

$$Corr(X,Y) = \frac{Cov(X,Y)}{\sqrt{Var(X)}\sqrt{Var(Y)}} \quad (1)$$

Similarly, [33] measures the dependence between units of variables:

$$corr(X,Y) = \frac{\sigma_{XY}}{\sigma_X \sigma_Y} \quad (2)$$

where correlation is unit and lies $[-1,1]$.

Pair-wise correlations: there are several ways of measuring the association between two variables. If two variables are measured in numbers, Spearman correlation is used, if two variables are categorical variables – Pearson correlation is used [31]. In addition, there are also other types of correlations such as list-wise, case-wise, pair-wise correlations.

To answer research objectives 3 and 4, we employ pair-wise correlations between measures of digitalization and microfinance indicators.

5. Results and findings

5.1. What are trends in digitalization?

There are several ways to measure digital adoption for countries across social and economic perspectives. To calculate the business focuses on digitalization, the Digital Adoption Index (DAI) covers three economic sectors: human, government, and business across 180 countries. The European Commission evaluates the progress of digitalization by following the Digital Economy and Society Index (DESI) focusing on EU countries. However, this index does not provide much information about rural developing countries.

MIX Market data helps to gather information about the unbanked in developing markets. Moreover, such indexes as the Digital Divided Index (DDI) measure technology adaptation and socioeconomic characteristics to evaluate the adaptation score. From the business perspective of digital technologies in EU countries, the European Investment Bank (EIB) Digitalization Index shows the rate of European companies' ability to implement digital and technological progress. Due to global modernization and digitalization, the IBM Global AI Adoption Index provides data on global adaptation to artificial intelligence and its contribution to business and society development.

To measure digitalization, we use the following 3 indicators:

(1) *Mobile cellular subscriptions* (per 100 people);

(2) *Individuals using the Internet* (% of the population);

(3) *Account ownership at a financial institution* or with a *mobile-money-service* provider for different ages of individuals.

Doi: https://doi.org/10.54216/FPA.120208
Received: January 25, 2023 Revised: April 24, 2023 Accepted: June 22, 2023

To show the dynamics in digitalization at the aggregate level, we group countries by income levels using the data are available in the World Bank's Data Catalog. Table 1 provides digitalization trends measured in mobile cellular subscriptions per 100 people for countries with different income levels. As can be seen, the highest levels of mobile cell users are in upper-middle-income countries and OECD countries which has been constantly increasing over the decade of 2010 – 2020, reaching the highest 119,56 in 2020. Low and middle-income countries and HIPS were also facing increasing coverage of mobile use although the rate is still retarding compared to upper-middle-income countries. They had 72,00 mobile cell users per 100 people in 20200 in HIPC, and 103,31 – in low and middle-income countries.

Table 1: Digitalization trends measured in mobile cellular subscriptions

Country groups:	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Heavily indebted poor countries (HIPC)	37,23	45,08	51,02	57,11	62,49	67,39	65,97	66,11	73,29	69,21	72,00
Low & middle income	69,24	77,64	82,28	87,43	90,98	92,35	96,08	98,72	102,51	103,70	103,31
OECD members	101,79	105,27	108,00	109,86	113,66	115,59	117,47	118,71	115,84	117,00	116,88
Upper middle income	81,73	89,04	96,16	103,57	105,79	105,60	108,04	111,27	118,26	121,83	119,56

Notes: country group classification is based on the methodology. Mobile cellular subscriptions are measured per 100 people.

Figure 1 illustrates the trends in mobile users. As can be seen, while there is a steadily increasing trend in users, HIPC countries are the most retarding group of countries.

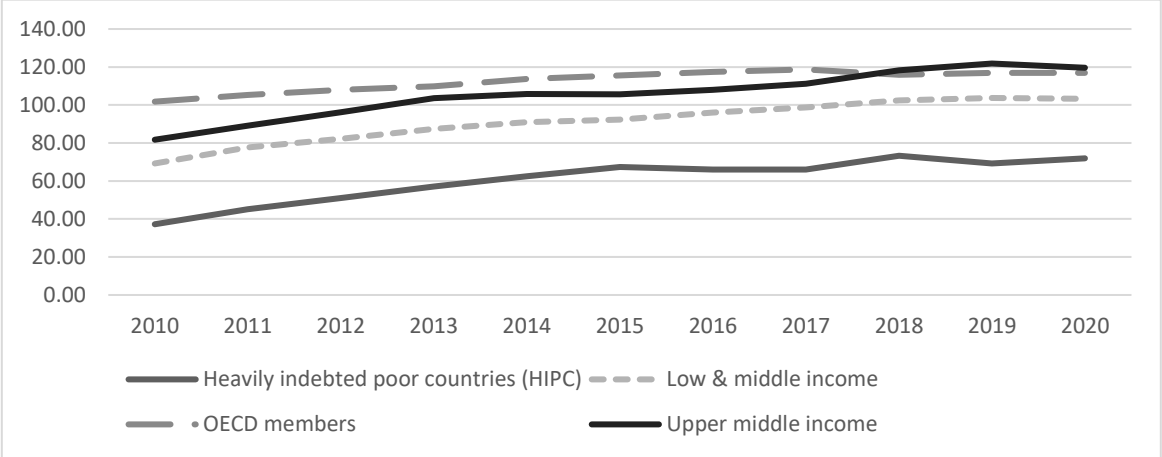

Figure 1: Dynamics for mobile cellular (per 100 people) for different countries

Digitalization is also measured by access to the internet of the population. Table 2 provides the dynamics of digitalization measured by individuals using the Internet as percent of population.

Doi: https://doi.org/10.54216/FPA.120208
Received: January 25, 2023 Revised: April 24, 2023 Accepted: June 22, 2023

Table 2: Digitalization trends measured by users of the Internet (% of population)

Country groups:	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Heavily indebted poor countries (HIPC)	3,39	3,99	4,98	6,03	7,90	10,56	13,17	16,51	20,19	22,57	25,04
Low & middle income	20,05	22,95	25,44	27,56	29,95	32,59	35,30	38,06	41,97	47,19	54,09
OECD members	66,53	67,54	70,19	71,54	73,14	75,69	79,83	81,45	83,37	85,18	86,29
Upper middle income	34,81	39,37	43,53	46,69	49,28	52,54	56,00	58,58	63,01	67,58	73,33

Notes: country group classification is based on the methodology. The users of Internet is measured in percent of population.

Figure 2 plots the trends in digitalization measured by Internet users. As can be seen, the lowest share of internet users are in HIPC countries, although this group of countries have been facing constantly increasing trend in digitalization.

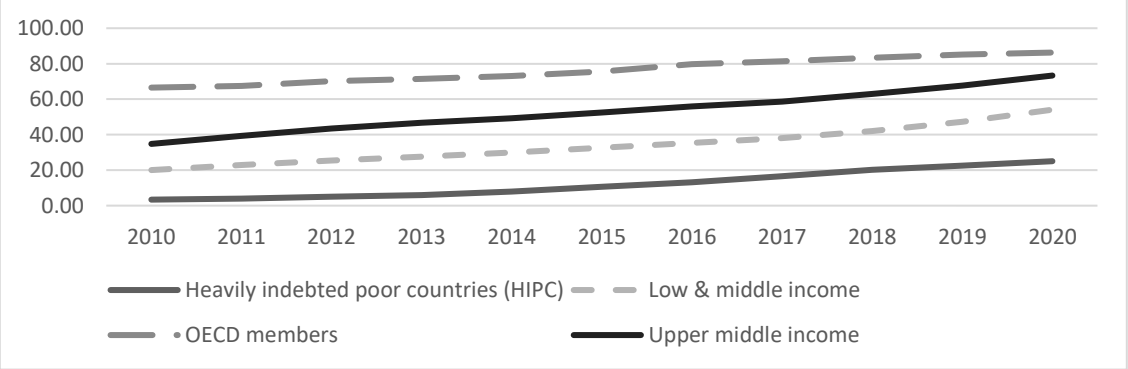

Figure 2: Individuals using the Internet (% of population) for different countries

We use the Digital Economy and Society Index (DESI) calculated for EU countries to demonstrate the tendency of the digitalization of countries in the EU. Table 3 provides the digital economy and society indexes for European countries from 2017-2022.

Table 3: Digital Economy and Society Index for the EU countries (2017-2022)

Groups:	2017	2018	2019	2020	2021	2022
European Union	33,72	35,92	38,64	41,67	46,20	52,28
Finland	47,85	50,37	54,14	58,43	63,16	69,60
Denmark	46,48	48,69	52,05	55,97	65,25	69,33
Sweden	45,71	48,74	51,96	55,75	60,49	65,22
Netherlands	45,59	48,06	50,52	54,68	62,36	67,37
Luxembourg	43,83	45,82	47,73	51,20	55,04	58,85
Malta	41,69	43,85	47,45	51,52	54,46	60,88
Estonia	41,34	43,98	46,57	49,05	53,15	56,51
Ireland	41,34	44,10	46,70	50,81	57,11	62,74
Spain	40,52	43,37	47,04	49,72	54,81	60,77
Latvia	37,40	39,40	40,98	44,06	46,13	49,71

Doi: https://doi.org/10.54216/FPA.120208
Received: January 25, 2023 Revised: April 24, 2023 Accepted: June 22, 2023

Lithuania	36,47	39,58	42,19	44,67	47,02	52,71
Austria	36,37	38,43	41,22	43,62	50,52	54,68
Belgium	35,73	38,04	40,00	44,24	46,71	50,31
Slovenia	35,70	37,86	40,89	42,92	47,96	53,37
Portugal	35,48	37,85	40,31	43,35	45,86	50,76
France	33,84	35,93	39,46	42,53	45,92	53,33
Germany	33,44	35,30	38,35	42,06	47,07	52,88
Czechia	31,83	34,19	37,19	39,54	43,37	49,14
Croatia	30,37	32,15	35,06	37,01	43,07	47,55
Slovakia	29,78	31,68	33,25	36,19	39,95	43,45
Cyprus	29,15	30,40	32,72	35,34	39,98	48,35
Hungary	28,26	30,11	32,18	35,84	38,72	43,76
Italy	28,16	30,56	34,34	36,72	40,85	49,25
Poland	24,93	27,12	29,78	33,20	36,53	40,55
Bulgaria	23,90	25,79	28,04	29,82	32,65	37,68
Greece	22,36	23,53	25,53	27,57	32,51	38,93
Romania	19,40	20,72	22,37	24,73	27,43	30,58

Due to the absence of this index for non-European countries, we use such indexes as Mobile cellular, Individuals using the Internet, and Account ownership at a financial institution or with a mobile-money-service provider for different income-valued countries. However, all indicators show an increasing number of users of digital applications (Figure 3).

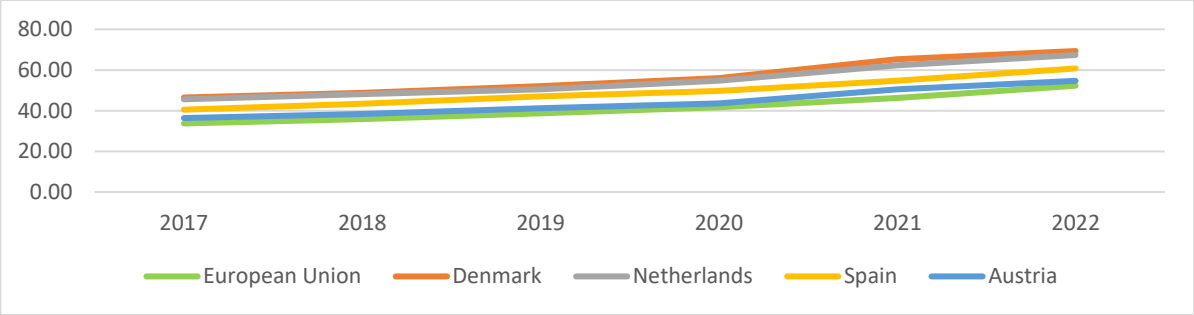

Figure 3: Digital Economy and Society Index (2017-2020)

Next, we move to the analysis of developing countries. To highlight the non-uniformity of MFIs, we focus on financial and social indicators from the MIX Market data that are available via the World Bank's Development Data Catalog.

5.2. Digitalization and microfinance

While digitalization is aimed to bring many positive aspects, in the context of microfinance it could bring potential challenges. The main reason is that microfinance is aimed to provide access to finance to low-income borrowers. As such, when microfinance services are provided to low-income borrowers – *moral hazard* and *asymmetric information* issues could be increasing.

In the microfinance context, microfinance institutions (MFIs) provide access to microcredits. Given that originally microfinance is aimed to provide access to credit to low-income households, the performance of MFIs is mainly measured by sets set of indicators: financial and social.

Doi: https://doi.org/10.54216/FPA.120208
Received: January 25, 2023 Revised: April 24, 2023 Accepted: June 22, 2023

For our analysis, we've chosen *five financial* and *five social indicators* that mostly reflect the criteria of efficiency, profitability, and social performance of microfinance institutions.

Financial indicators of microfinance:	*Social indicators of microfinance:*
(1) Average assets	(1) Average loan balance per borrower
(2) Average Gross Loan Portfolio	(2) Average number of active borrower
(3) Financial Revenue	(3) Number of active borrowers
(4) Gross Loan Portfolio	(4) Number of active borrowers
(5) Operative Expenses	(5) Percent of female borrowers (%)

We gather aggregate levels of the chosen indicators through available MFIs per country and calculate the weighted level of each indicator per country over time. In this way, we obtain the growth/degradation dynamic of weighted indicators by countries over six years.

Table 4: Pairwise correlations Digital Ranking and Financial Indicators by countries (2013-2018)

		(1) Average Assets	**(2) Average Gross Loan Portfolio**	**(3) Financial Revenue**	**(4) Gross Loan Portfolio**	**(5) Operating Expense**
South America	(1) Argentina	0.206 (0.695)	0.350 (0.496)	0.647 (0.165)	0.441 (0.382)	0.798 (0.057)
	(2) Brazil	0.480 (0.336)	-0.037 (0.945)	-0.222 (0.673)	0.131 (0.804)	0.017 (0.974)
	(3) Colombia	-0.663 (0.151)	-0.513 (0.299)	-0.657 (0.156)	-0.479 (0.337)	-0.592 (0.215)
Asia	(4) India	-0.619 (0.190)	-0.612 (0.196)	-0.553 (0.255)	-0.613 (0.195)	-0.581 (0.227)
	(5) Indonesia	0.380 (0.457)	0.367 (0.474)	0.419 (0.408)	0.405 (0.426)	0.542 (0.266)
	(6) Kazakhstan	0.248 (0.635)	0.184 (0.727)	-0.083 (0.876)	0.382 (0.455)	-0.135 (0.798)
	(7) Philippines	0.826 (0.043)	0.828 (0.042)	0.936* (0.006)	0.830 (0.041)	0.880 (0.021)
Europe and Asia	(8) Russia	0.933* (0.007)	0.935* (0.006)	0.059 (0.912)	-0.041 (0.939)	0.372 (0.468)
	(9) Poland (2013-2015)	0.979 (0.130)	0.972 (0.151)	0.008 (0.995)	0.489 (0.675)	0.609 (0.583)
	(10) Turkey (2013-2015)	-0.601 (0.590)	0.936 (0.230)	0.686 (0.519)	0.262 (0.831)	0.835 (0.371)

In addition, we use the IMD World Digital Competitiveness (WDC) ranking that ranges the levels of countries' adaptation to digital technologies. The methodology of WDC consists in evaluating competitiveness among countries based on three factors: knowledge, technology, and future readiness. In turn, each of the aggregated factors is divided into 3 sub-factors that differ in the number of criteria they contain and in how the data is measured. The higher the WDC rank, the more innovative the country.

5.3. What are the correlations between digitalization and microfinance indicators?

In this section, we present the correlation between the level of digitalization and financial and socio-economic weighted indicators by countries. We match the list of countries for which the WDC ranking is available with countries from MIX Market data and stop by ten countries with different geographical locations.

Table 4 provides the correlation table for digitalization as measured by digital ranking and microfinance and financial indicators. As can be seen from Table 4, the sign of pair-wise correlations between digitalization and

Doi: https://doi.org/10.54216/FPA.120208
Received: January 25, 2023 Revised: April 24, 2023 Accepted: June 22, 2023

microfinance financial indicators is mixed, i.e. while some countries reveal negative correlations (i.e. Brazil, Colombia, India, Turkey). Positive statistically significant correlations are observed in the Philippines and Russia.

From this correlation analysis, we can infer that digitalization is positively associated with microfinance service provision and the financial sustainability of microcredit providers. While negative correlations are mostly found insignificant, they provide a strong message that in the context of microfinance, digitalization could bring negative harm. These results convey important policy implications for developing countries. Heavy digitalization could

Table 5: Pairwise correlations Digital Ranking and Social Indicators by countries (2013-2018)

		(6) Average loan balance per borrower	**(7) Average number of active borrowers**	**(8) Number of active borrowers**	**(9) Number of active borrowers**	**(10) Percent of female borrowers (%)**
South America	1) Argentina	0.435 (0.389)	-0.385 (0.452)	0.541 (0.268)	-0.391 (0.444)	-0.189 (0.719)
	2) Brazil	-0.073 (0.890)	0.662 (0.152)	0.792 (0.060)	0.293 (0.573)	0.509 (0.302)
	3) Colombia	-0.474 (0.342)	0.727 (0.102)	0.164 (0.755)	0.526 (0.284)	-0.775 (0.070)
Asia	(4) India	-0.669 (0.146)	-0.136 (0.797)	-0.337 (0.514)	0.932* (0.007)	0.398 (0.435)
	(5) Indonesia	-0.818 (0.047)	0.419 (0.408)	0.401 (0.430)	0.398 (0.434)	-0.480 (0.336)
	(6) Kazakhstan	-0.388 (0.448)	-0.015 (0.977)	0.058 (0.913)	0.032 (0.952)	-0.203 (0.700)
	(7) Philippines	-0.897 (0.015)	0.944* (0.005)	0.693 (0.127)	0.914 (0.011)	-0.164 (0.757)
Europe and Asia	(8) Russia	0.183 (0.728)	0.893 (0.016)	0.875 (0.023)	0.889 (0.018)	0.548 (0.261)
	(9) Poland (2013-2015)	-0.173 (0.889)	0.108 (0.931)	-0.040 (0.974)	-0.331 (0.785)	-0.637 (0.560)
	(10) Turkey (2013-2015)	0.548 (0.631)	-0.776 (0.434)	-0.910 (0.272)	-0.910 (0.272)	-

lead to potentially negative financial outcomes for MFIs. Therefore, careful consideration is needed when promoting digitalization in microfinance context. Table 5 reports pairwise correlations between digitalization and microfinance social indicators. As can be observed, most of the pair-wise correlations are negative, although not significant. Particularly, (1) the average loan balance per borrower is consistently negative for most of the countries, i.e. Brazil, Colombia, Indonesia, Kazakhstan, Philippines, and Poland. (10) Percent of female borrowers (%) is negative in Argentina, Colombia, Kazakhstan, Philippines. Positive correlations are observed in India for (9) the number of active borrowers and in the Philippines (7) the average number of active borrowers.

Correlations of digitalization with microfinance social indicators reveal potential pitfalls of digitalization for low-income borrowers who are mainly clients of microfinance programs. Given that microfinance programs were originally introduced to help poor women to start their small businesses, our results also imply capturing gender aspects of digitalization too. (5) Percent of female borrowers (%) is found negative in Argentina, Colombia, Kazakhstan, and Philippines.

6. Conclusion

In this paper we've reviewed main trends in digitalization, technology fusion. Using three measures of digitalization we analyzed how digitalization is evolved in different group of countries by income profile. Our second contribution on digitalization is that we bring to the attention of readers and researchers on what are

Doi: https://doi.org/10.54216/FPA.120208
Received: January 25, 2023 Revised: April 24, 2023 Accepted: June 22, 2023

potential challenges and pitfalls of digitalization. In areas that require high human interaction, extensive reliance on technology and digitalization could lead to information asymmetries such as moral hazard and asymmetric information. This is mainly since lenders do not observe borrowers, and borrowers know that their actions will not be monitored. In normal setting, such as classical banking, these information asymmetries should not prevail. Yet, in context of microfinance, where borrowers tend to be high risk profile, moral hazard and information asymmetries could prevail, if the microfinance provision is heavily digitalized. Thinking the long-term perspective, our study provides thought provoking ideas on hidden challenges of digitalization. We provide first evidence from microfinance context. Conducting pair-wise correlations, we find that digitalization is negatively correlated with key financial and social indicators of microfinance. This result implies on potential risks of digital technologies. Further research is needed on theatrical modeling of challenges and risks associated with digitalization. Also, further research on pitfalls of digitalization, fusion of technologies, is recommended in other domains of socio-economic activities, such as medical care, insurance, other service provision.

Funding: "This research received funding from Czech Science Foundation (GAČR), project no. 19-19158S".

Conflicts of Interest: "The authors declare no conflict of interest."

References

[1] Marshall, J. M. (1976). Moral hazard. *The American Economic Review, 66*(5), 880-890.
[2] Mishkin, F. S. (1990). Asymmetric information and financial crises: a historical perspective.
[3] Morduch, J. (1999). The microfinance promise. *Journal of Economic Literature, 37*(4), pp. 1569-1614.
[4] Mersland, R., & Strøm, R. Ø. (2012). The Past and Future of Innovations in Microfinance. Oxford Handbooks Online. doi:10.1093/oxfordhb/9780195391244.013.0028
[5] Armendáriz, B., & Morduch, J. (2010). The economics of microfinance. MIT press.
[6] Goldstein, I., Jiang, W., & Karolyi, G. A. (2019). To FinTech and beyond. *The Review of Financial Studies, 32*(5), 1647-1661.
[7] Alshebami, A. S., Rengarajan, V., Pahlevi, R. W., Said, J., & Sari, W. R. (2021). Challenges and Risk of Microfinance Sustainability amid Covid-19 Pandemic Crisis. *Academy of Strategic Management Journal, 20*, 1-5.
[8] Benami, E., & Carter, M. R. (2021). Can digital technologies reshape rural microfinance? Implications for savings, credit, & insurance. *Applied Economic Perspectives and Policy.*
[9] Jalil, M. F. (2021). Microfinance towards micro-enterprises development in rural Malaysia through digital finance. *Discover Sustainability, 2*(1), 1-15.
[10] Gupta, S., Dhawan, A., Gupta, A., & Dubey, A. K. (2021). Facial Expression Recognition with Gender Identification. *Fusion: Practice and Applications, 2*(2), 57-7.
[11] Dorfleitner, G., Forcella, D., & Nguyen, Q. A. (2021). The digital transformation of microfinance institutions: an empirical analysis. *Journal of Applied Accounting Research.*
[12] Vogeley, J., & Delaram, L. (2017). Impact of Digital Technologies on Social Productivity growth of Microfinance Institutions in Indonesia. 3rd International Conference on Transformation in Communications 2017 (IcoTiC 2017). Atlantis Press, 2017.
[13] Mujeri, M. (2020). Digital Transformation of MFIs: A Post Covid-19 Agenda for Bangladesh. Working Paper No. 63.
[14] Alsayadi, H., El-Sayed M., l-Kenawy , Abdelhameed, I., Marwa M., Abdelaziz A. (2022). Blog Feedback Prediction based on Ensemble Machine Learning Regression Model: Towards Data Fusion Analysis. *Fusion: Practice and Applications, 9* (1), 38-46.
[15] Kauffman, R. J., & Riggins, F. J. (2012). Information and communication technology and the sustainability of microfinance. *Electronic Commerce Research and Applications, 11*(5), 450-468.
[16] Greenacre, J. (2009). Welcome to the digital age: Mobile phones and microfinance. *GITAM Review of International Business, 1*(2), 61.
[17] Ratan, A. L., Toyama, K., Chakraborty, S., Ooi, K. S., Koenig, M., Chitnis, P. V., & Phiong, M. (2010, December). Managing microfinance with paper, pen and digital slate. In Proceedings of the 4th ACM/IEEE International Conference on Information and Communication Technologies and Development (pp. 1-11).
[18] Robinson, J., Park, D. S., & Blumenstock, J. E. (2022). The Impact of Digital Credit in Developing Economies: A Review of Recent Evidence. UC Berkeley CEGA Working Papers.

Doi: https://doi.org/10.54216/FPA.120208
Received: January 25, 2023 Revised: April 24, 2023 Accepted: June 22, 2023

[19] Thomas, T., & Suresh, T. S. (2020). Digital financial inclusion: a catalyst for socio-economic transformation of scheduled castes and scheduled tribes in Kerala. IOSR Journal of Business and Management (IOSR-JBM), 22(5), 18-26.
[20] Faustin, G., & Harelimana, J. B. (2016). Mobile Banking and Microfinance Institutions Sustainability: Analysis of Digital Financial Services in Rwanda (2011-2015). *Journal of Economics, Management and Trade,* 1-12.
[21] Malarvizhi, P., Munjal, P. (2016). Microfinance In India – Digital Financial Inclusion. International Journal of Science, Technology and Management, 5 (12).
[22] Tripathi, V. K. (2014). Microfinance-evolution, and microfinance-growth, of India. *International Journal of Development Research, 4*(5), 1133-1153.
[23] Kienzle L. and Maloba H. (2015) Microfinance goes digital: Opportunities and Challenges in enabling pro-poor financial institutions to connect to the digital ecosystem 2015. https://nextbillion.net/three-ways-the-mobile-finance-ecosystem-can-reach-the-next-level/
[24] Masiero, S., and Ravishankar, M. N. (2018) Digital social entrepreneurship: Balancing social and commercial goals in an Indian 'FinTech' organization, Proceedings of the 34 th EGOS Colloquium.
[25] Sharma, A., & Sharma, J. K. (2020). Evolving landscape of microfinance in India: Challenges & revival strategies. *Asian Journal of Research in Banking and Finance, 10*(10), 1-13.
[26] Ozili, P. K. (2020). Contesting digital finance for the poor. *Digital Policy, Regulation and Governance, 22(*2), 135-151.
[27] Ahmad, A. H., Green, C., & Jiang, F. (2020). Mobile money, financial inclusion and development: A review with reference to African experience. *Journal of Economic Surveys, 34*(4), 753-792.
[28] Ashta, A. (2018). News and trends in Fintech and digital microfinance: Why are European MFIs invisible? *FIIB Business Review, 7*(4), 232-243.
[29] Pytkowska, J., & Korynski, P. (2017). Digitalizing Microfinance in Europe. Microfinance Centre.
[30] Siwale, J., & Godfroid, C. (2022). Digitizing microfinance: on the route to losing the traditional 'human face' of microfinance institutions. *Oxford Development Studies, 50*(2), 177-191.
[31] Gujarati, D. N. (2022). Basic econometrics. Prentice Hall.
[32] Pearson, K. (1895), Royal Society Proceedings, 58, 241.
[33] Stock, J. H., & Watson, M. W. (2003). Introduction to econometrics (Vol. 104). Boston: Addison Wesley.
[34] Wooldridge, J. M. (2015). Introductory econometrics: A modern approach. Cengage learning.

Doi: https://doi.org/10.54216/FPA.120208
Received: January 25, 2023 Revised: April 24, 2023 Accepted: June 22, 2023