



IMPACT OF DIGITALIZATION ON FIRMS' PRODUCTIVITY

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ABSTRACT

Employing Enterprise Survey data that comprises 1276 firms from four Central Asian countries, this study focuses on the impact of digitalization as well as human capital on firms' productivity. We have found that digitalization improves firms' productivity by 44-52 percent on average, statistically significant at 1%. Moreover, analysis shows that the impact is heterogeneous, with large and statistically significant effects for firms in retail, nonmetal, and, especially, textile industries. These results imply that digitalization is crucial in improving firms' productivity and the government could implement policies that encourage and help firms with this regard.

CCS CONCEPTS

• firms' productivity; • digitalization; • industries; • heterogeneous impacts; • textile; • wholesale; • retail; • nonmetal industry; • human capital;

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1 INTRODUCTION

In today's modern world, digitalization has already become a common element nearly in each part of our life. It has been used in different fields, like production, household, government structures, banking, education, agriculture, healthcare, and business.

The main purpose of digitalization is to increase the operational efficiency of the firm, lower the costs, improve the quality of the product, and of course, make people's lives easier. Margrethe Vestager, the Executive Vice-President for a Europe Fit for the Digital Age, Margrethe Vestager, states that the process of digitalization is becoming accelerating and most Member States of Europe are progressing in building resilient digital economies.

In fact, according to the digital economy and society index (DESI), most of the EU Member States have shown good progress during the last five years. It is strongly believed that digital transformation

helps companies increase their productivity by enabling them to gather data on specific performance metrics and measure each. Furthermore, it improves the inter and intra departmental connection.

Hence, digitalization is considered to be an important factor in improving the productivity of the firms in the developing countries. With this regard, in this research, we investigate:

- the impact of digitalization on the firms' productivity,
- whether this impact is heterogeneous across industries,
- whether the impact is robust to model specifications.

A huge number of studies have been conducted to estimate the impact of digitalization on productivity. However, there are only few studies that focus on FDI in Central Asia or Post soviet countries, and they are mainly on the macro level. Our study is different from previous studies with that our study: (1) focuses on human capital on the effectiveness of digitalization on the firms' productivity; (2) considers the Central Asian region only; (3) utilizes the most updated data.

LITERATURE REVIEW

Various research has been conducted on the topic of digitalization and its impact on firms' productivity. Some studies have found this impact positive. For example, according to data, the companies in China showed a significant improvement because of digitalization between 2012 and 2019 [1]. In addition, some research shows that digitalization caused the rise of the number of high-skilled workers instead of low-skilled ones, which had a positive impact on firms [2].

On the other hand, however, there are some researchers that truly believe that computerizing can affect the companies in a negative way. For instance, in Latin America, the firm's performance declined, as they couldn't capitalize on the benefits of market digitalization [3].

Moreover, there exist many different studies around the topic of digitalization, which is related to various fields like accounting, supply chains, retail businesses and others. The one conducted by A. Babayeva and N.D. Manousaridis states that auditors are satisfied with the overall impact of digitalization on their field, and they seem to be open to using more technology in their work routines [4].

Zhang, H., Gao, S. and Zhou, P. made their research on the role of digitalization in energy storage development and have found that the digitalization positively promotes technological innovation in energy storage, of which digitization and Internet of Things strategy make more decisive contributions [16].

More interestingly, Joensuu-Salo, S., Sorama, K., Viljamaa, A. and Varamäki, E. in their research have found that for internationalized firms digitalization had no effect. However, there was a significant effect of digitalization on the performance of the firms which operate in their domestic markets [17].

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Table 1: Descriptive statistics: food, retail, and construction industries

Variable	food			retail			construction		
	Obs	Mean	St. Dev.	Obs	Mean	St. Dev.	Obs	Mean	Std. Dev.
lsales	414	9.18	1.32	424	9.57	1.46	200	9.7	1.58
website	474	0.38	0.49	523	0.36	0.48	234	0.33	0.47
lemp	474	3.28	1.31	523	2.83	1.27	234	3.3	1.39
emp uni	184	4.90	3.39	187	4.81	3.18	81	6.11	2.77
train	474	0.23	0.42	523	0.3	0.46	234	0.24	0.43
randd	474	0.25	0.43	523	0.13	0.34	234	0.15	0.35
asset	474	0.39	0.49	523	0.22	0.41	234	0.44	0.5
age	460	14.25	15.31	519	12.78	8.99	234	13.31	11.09
for share	460	4.13	17.12	514	5.07	20.73	232	2.28	13.49
country									
Uzbekistan	474	0.33	0.47	523	0.29	0.45	234	0.29	0.46
Kazakhstan	474	0.46	0.5	523	0.38	0.49	234	0.41	0.49
Kyrgyz Rep.	474	0.1	0.3	523	0.19	0.39	234	0.1	0.3
Tajikistan	474	0.1	0.3	523	0.14	0.35	234	0.19	0.39

Other research shows that there is not a significant difference between digitally mature firms' stock returns and the returns of less digitally mature firms. Also, the scholar claims that the digital maturity is linked to a lower subsequent operating performance, as digitalization's conjectural positive effects on firms are not supported [18].

Kronblad C. suggests that digitalization enables legal service delivery at lower levels of knowledge intensity, whereas it increases capital intensity for most firms and decreases the professionalization of the workforce. His findings show that digitalization has changed the distinctive characteristics of professional service firms, which promotes new practices, allows for variation, and transforms their competitive contexts [19].

Human resource management is considered to be one of the most important components of a firm. From this point of view, Muhammad Zeshan, Tahir Masood Qureshi and Irfan Saleem, in their paper about impact of digitalization on employee's autonomy, have found that there is a positive relationship between digitalization and employees' autonomy. They suggested that an enabling control based HRM system mediates the positive relationship between digitalization and autonomy [20].

2 DATA AND METHODOLOGY

We adopt a Cobb-Douglas production function, as in most prior research. We have the production function as:

$$Y = AK^{\alpha}L^{1-\alpha} \quad (1)$$

Dividing both sides by L leads to:

$$\frac{Y}{L} = A \left(\frac{K}{L} \right)^{\alpha} \quad (2)$$

We then take the log of this equation, and transform it into a linear function:

$$\ln \left(\frac{Y}{L} \right) = \ln A + \alpha \ln \left(\frac{K}{L} \right) \quad (3)$$

In the equation (3), the left-hand side can be regarded to represent the productivity of the firm. Further, we estimate the following model to determine the impact of digitalization on firms' productivity:

$$\ln Y_i = \beta_1 L_i + \beta_2 K_i + \beta_3 \text{website}_i + \beta_4 I_i + \beta_5 C_i + X' \beta + \epsilon_i \quad (4)$$

where y_i is sales per worker, L is set of variables for labor, K is variables for capital, website is a dummy variable for whether a firm owns a website, I is a set of industry dummies, C is a set of country dummies, X is a set of other exogenous variables that could affect firm's productivity, and ϵ_i is an error term. That is, firms' productivity is represented by sales per worker while dummy variable for owning website is used as a proxy for digitalization of the company.

We then conduct subsample analysis, using the same model for the largest economic sectors. The main problem of estimating this model is the endogeneity problem. Although we tried to include all available variables in the regression, it is still difficult to claim causality.

This study utilizes the Enterprise Survey (ES) data provided by the World Bank as a part of a joint project of the European Bank for Reconstruction and Development (EBRD), the European Investment Bank (EIB) and the World Bank Group (WBG). The surveys are conducted in all countries of the world, covering the representative sample of small, medium, and large companies in the private sector. The surveys provide useful information regarding the establishment, infrastructure, sales, competition, innovation, capacity, labor, performance of the firms and other important relevant topics.

We employ the 2019 cross-sectional ES datasets for four countries: Uzbekistan, Kazakhstan, Tajikistan, and Kyrgyz Republic (no survey is available for Turkmenistan).

Table 1 and Table 2 illustrates the summary statistics of the variables for the four countries. Since lsales is log of sales, we can calculate that the largest average annual sales are observed in the wholesale industry, with about 29 thousand USD on average.

Table 2: Descriptive statistics: textile, nonmetal, and whole industries

Variable	textile			nonmetal			wholesale		
	Obs	Mean	St. Dev.	Obs	Mean	St. Dev.	Obs	Mean	St. Dev.
lsales	317	8.46	1.74	293	9.5	1.38	177	10.27	1.77
website	354	0.4	0.49	342	0.41	0.49	214	0.55	0.5
lemp	354	3.39	1.44	342	3.3	1.27	214	2.94	1.31
emp uni	121	4.80	1.06	135	4.48	2.94	62	7.03	3.35
train	354	0.18	0.39	342	0.19	0.4	214	0.33	0.47
randd	354	0.16	0.37	342	0.2	0.4	214	0.15	0.36
asset	354	0.41	0.49	342	0.4	0.49	214	0.33	0.47
age	349	12.84	13.29	339	12.3	11.75	213	11.74	10.12
for share	349	8.23	25	338	5.86	20.43	212	4.99	19.13
country									
Uzbekistan	354	0.64	0.48	342	0.44	0.5	214	0.21	0.41
Kazakhstan	354	0.26	0.44	342	0.44	0.5	214	0.52	0.5
Kyrgyz Rep.	354	0.04	0.2	342	0.1	0.3	214	0.12	0.33
Tajikistan	354	0.06	0.25	342	0.03	0.17	214	0.15	0.36

Moreover, the wholesale sector seems to be the largest digitized sector, where 55% of firms own a website. In all other sectors, 30-40% of the firms run a website. As per number of employees, about 17-30 thousand workers are employed in the firms on the average (the table shows the natural logarithm of the numbers). Further, looking at the percentage of the employees who graduated from university, we can see that the share is not large across the industries. We again see that the wholesale sector dominates the list with slightly more than 7% of the workers with higher education and 33% of the firms have trained their employees. It is interesting that the wholesale sector overall looks more productive compared to other sectors in terms of human capital and digitalization.

Regarding Research and development expenditures, we can see that the majority of the firms haven't spent any money on it. Only about 15-20% of the firms on average have reported that they had such expenditures. Further, we can see that the average firm is relatively young, established only 10-14 years ago. When it comes to foreign investments, they are almost stable across countries, with about 5% of the firms owned by foreign investors, while only for the textile industry the number is higher – 8%.

As per geographic location, Uzbekistan seems to own the majority of the textile companies, whereas Kazakhstan has the largest number of wholesale firms. Firms located in Kyrgyz Republic and Tajikistan constitute a relatively smaller share of the sample, with Kyrgyz firms mostly majoring in retail industry and Tajikistan has larger share in construction industry.

3 RESULTS AND DISCUSSION

Table 3 shows OLS regression results with different model specifications adding variables of state ownership, number of competitors, dummy for locating in business city, and manager's experience to the main model. It is clear that the models explain 24,1-26,8% of the variation in sales per worker. On average, the firms that own websites have 44-52% more productivity compared to those that don't have online platforms, and impact does not change much and

remains large even after adding new variables to the model. Moreover, 1% increase in the share of workers with higher education increases productivity by 0.35-0.41% on average, holding all other factors fixed. Although impact of foreign ownership is statistically significant at 10%, economic magnitude of impact is negligible. The additional variables turn out to be not statistically significant at 10% (manager's experience is an exception), however they are helpful to decrease the standard errors of other more important variables. It is interesting though that neither research and development costs have any impact on firms' productivity. It might be because firms allocate very little money on it.

Next, we check if the impact is heterogeneous across industries. Table 4 illustrates the results of the same regression within the largest industries. It is clear that selected variables explain from 21,3% to 36,6% of the variation in firms' productivity. The table shows that impact of digitalization on the firms' productivity is statistically significant for firms in retail, textile, and nonmetal industry, with the textile firms having the largest magnitude coefficient (51,9%). This result is expectable and consistent with the current trends of increasing online shopping. We expect that these impacts have become even larger after Coronavirus pandemics, considering that increasing demand for shopping from home has accelerated the process of digitalization.

Moreover, we can observe that human capital (number of employees with higher education) has a significant impact on the retail and textile sector. These characteristics of the textile and retail industry could possibly be explained with a more competitive market in these industries compared to other sectors.

We further notice that having employees trained increases productivity significantly only in the retail sector, while R&D costs are still insignificant in all of the industries. Whether a company acquired any asset in the last year matters for retail and, especially, for construction industry firms, which is expected. Foreign investment again has a significant, but economically small impact in retail, textile, and nonmetal industries (the impact is negative for nonmetal industry, but, again, does not have economic significance). Another

Table 3: Impact of digitalization on firms' productivity

	(1) lsales	(2) lsales	(3) lsales	(4) lsales	(5) lsales
website	0.525 ^{***} (0.175)	0.525 ^{***} (0.175)	0.482 ^{***} (0.169)	0.455 ^{***} (0.167)	0.443 ^{***} (0.164)
lemp	-0.046 (0.081)	-0.049 (0.082)	-0.047 (0.081)	-0.030 (0.080)	-0.023 (0.080)
emp_uni	0.411 ^{***} (0.109)	0.409 ^{***} (0.109)	0.380 ^{***} (0.109)	0.358 ^{***} (0.108)	0.346 ^{***} (0.106)
train	0.291 (0.194)	0.291 (0.194)	0.258 (0.193)	0.208 (0.192)	0.236 (0.190)
randd	-0.078 (0.197)	-0.079 (0.197)	-0.098 (0.197)	-0.117 (0.195)	-0.132 (0.195)
asset	0.224 (0.166)	0.224 (0.166)	0.233 (0.158)	0.223 (0.158)	0.237 (0.156)
age	-0.008 (0.009)	-0.008 (0.009)	-0.006 (0.008)	-0.006 (0.008)	0.005 (0.009)
for_share	0.007 [*] (0.004)	0.007 [*] (0.004)	0.007 [*] (0.004)	0.007 [*] (0.004)	0.007 [*] (0.004)
state		0.004 (0.005)	0.004 (0.005)	0.004 (0.005)	0.001 (0.005)
compet			-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
bus_city				0.211 (0.153)	0.222 (0.153)
man_exper					-0.014 [*] (0.008)
country dummies	yes	yes	yes	yes	yes
industry dummies	yes	yes	yes	yes	yes
_cons	8.510 ^{***} (0.239)	8.518 ^{***} (0.244)	8.641 ^{***} (0.255)	8.531 ^{***} (0.247)	8.658 ^{***} (0.255)
N	2801	2801	2801	2801	2771
R ²	0.241	0.241	0.256	0.260	0.268

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Impact of digitalization by economic sectors

	(1) food	(2) retail	(3) construction	(4) textile	(5) nonmetal	(6) wholesale
website	0.120 (0.148)	0.378*** (0.161)	0.159 (0.257)	0.519** (0.220)	0.356* (0.187)	0.383 (0.261)
lemp	0.122* (0.069)	-0.134* (0.071)	0.079 (0.099)	-0.077 (0.085)	0.150* (0.084)	-0.105 (0.123)
emp_uni	0.024 (0.096)	0.265** (0.111)	0.262 (0.203)	0.461*** (0.150)	-0.137 (0.130)	0.177 (0.202)
train	0.120 (0.169)	0.497*** (0.169)	0.141 (0.274)	0.045 (0.274)	0.267 (0.204)	-0.062 (0.297)
randd	0.205 (0.164)	-0.053 (0.223)	0.081 (0.346)	0.013 (0.276)	0.125 (0.203)	0.272 (0.410)
asset	0.066 (0.139)	0.360** (0.182)	0.655*** (0.235)	-0.072 (0.198)	0.016 (0.167)	-0.170 (0.276)
age	0.005 (0.005)	-0.012 (0.009)	-0.007 (0.012)	0.004 (0.009)	-0.013 (0.010)	0.029** (0.015)
for_share	0.005 (0.004)	0.007* (0.004)	0.008 (0.008)	0.010** (0.004)	-0.009** (0.004)	0.006 (0.007)
state	-0.060*** (0.006)	-0.013* (0.008)	-0.008 (0.021)	-0.040*** (0.017)	-0.011 (0.009)	0.002 (0.012)
compet	0.000 (0.000)	-0.000** (0.000)	0.000 (0.000)	-0.000 (0.000)	-0.000* (0.000)	0.010*** (0.000)
bus_city	0.193 (0.163)	-0.000 (0.168)	-0.211 (0.310)	-0.121 (0.241)	0.594*** (0.218)	-0.051 (0.301)
man_exper	0.009 (0.007)	-0.008 (0.008)	0.001 (0.010)	0.002 (0.010)	0.002 (0.009)	0.007 (0.016)
country dummies	yes	yes	yes	yes	yes	yes
_cons	8.316*** (0.232)	9.858*** (0.284)	8.299*** (0.466)	7.759*** (0.360)	8.930*** (0.288)	10.351*** (0.511)
N	404	412	195	311	287	173
R ²	0.213	0.250	0.282	0.212	0.289	0.366

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

interesting result can be seen for state ownership of the firms. We can see that one more percentage increase in state ownership decreases productivity by 0.06, 0.013, and 0.040 percentage points in food, retail, and textile industries, respectively. Locating in a business city matters only for nonmetal industry. Finally, neither

number of competitors, nor managerial experience seems to be significant across all industries.

4 CONCLUSION

In this research, we have employed a survey of 1276 firms in Central Asia to study the impacts of digitalization on firms' productivity, investigating the heterogeneous impact of digitalization on the firms' productivity and its robustness to model specifications.

Simple OLS regression results show that digitalization improves firms' productivity by 44-52 percent on average, holding unobservable variables fixed. This result is statistically significant at 1% and proved to be robust when we included several different variables to the model.

Further, when we explore the heterogeneity of the impact across industries, we find that the impact is large and statistically significant for firms in retail, nonmetal, and, especially, textile industries, as textile firms who own a website are 51,9% more productive compared to those that do not own one.

This research could further be continued if new rounds of the enterprise survey were available for public using. This would let us use more advanced methods like fixed/random effect models to reduce endogeneity bias and identify pure causal effect.

These results imply that digitalization is crucial in improving firms' productivity and the government could implement policies that encourage and help firms with this regard.

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