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The use of computers and the Internet - effects on employee productivity in Romania

Ionela Tofan

Alexandru Ioan Cuza University of Iași, Doctoral School of Economics and Business Administration, Iași, Romania

itofan08@yahoo.com

Kamer-Ainur Aivaz

“Ovidius” University of Constanta, Faculty of Economic Sciences, Constanța, Romania

kamer_aivaz@yahoo.com

Abstract. The efficient use of the human potential, the increase of the labour productivity is reflected directly or indirectly, in the entire system of economic and financial indicators of the enterprise and on the economy as a whole. In order to create a link between technology/digitalisation and labour we used in this paper the data for the period 2012-2020 for two indicators: Labour productivity per person employed, by activities of the economy (RON/person) taken from the database of the National Institute of Statistics in Romania and Use of computers and the Internet by employees taken from Eurostat (Department of the European Commission responsible for publishing comparable statistics for the entire territory of the EU).

Keywords: workforce, labour productivity, digitalisation/technological impact.

1. Introduction

Labour and productivity growth are concepts analysed by economists, for centuries.

Since the industrial revolutions, the key research questions have been whether technological progress/digitisation influences employment, whether it abolishes jobs or creates new ones, whether employee productivity increases exponentially.

With this study we conducted an exploratory analysis of the effects of computer and internet use by employees on the labour productivity of employed people in Romania, using data for the period 2012-2020.

The economic literature concerned with analysing the link between labour productivity and the impact of technology/digitalisation is concentrated in America, Asia and in recent years also in Europe.

"The Future of Employment" prepared by Karl Frey and Michael Osborne, at the 2013 Oxford University "Machines and Employment" Workshop is motivated by John Maynard Keynes often-quoted prediction of large-scale technological unemployment "due to our discovery of means of saving the use of labour outstripping the rate at which we can find new uses of labour" (Keynes, 1970). The original Frey-Osborne study focused on American labour data and predicted that in the next twenty years nearly half the current number of jobs in the US may be taken over by robots and computers. Their follow-up work estimated similar conclusions for Britain and Europe.

Over the past decades, computers have replaced a range of jobs, including the functions of accountants, cashiers and telephone operators (Bresnahan, 1995; McKinsey Global Institute, 2017).

A few decades ago, Brynjolfsson described the "productivity paradox" and argued that the link between IT and productivity is rather hard to prove (Brynjolfsson, 1993). Also, the studies developed by Brynjolfsson and McAfee (2013, 2014) are creating a bridge between technology and productivity and economic growth: they believe that technological innovations are creating economic growth, but not jobs growth.

Davenport (2011) pointed out that there is no direct link between massive spending on technology and employee productivity growth.

Ford (2015), Acemoglu and Restrepo (2017) have analysed the consequences for employment as a result of full or partial replacement of jobs with machines or redundant/demanding tasks.

There is a group of optimist economists which predicts that new technology may lead to extreme productivity growth and a period of abundance (Rifkin, Kurzweil, Diamandis and Kotler, 2011). Their ideas are popular among politicians from Berlin, Brussels and even Beijing.

Information and communication technologies (ICT) have significantly impacted the world of work (Micu et al., 2021). The types of available jobs, the way work is carried out, and even the process of acquiring job positions is changing (Raja et al., 2013). Aivaz (2020) argued that ICT is a significant part of the strategies formulated not only at national level, but also at business level, because they allow easier and faster communication globally. Any improvement brought to these activities contributes to their integration into the economic activity by improving the business methods and implicitly increasing the living standard.

If we look at the definitions of the digital workplace from Gartner (2016b) and Tubb (2013), the digital knowledge workplace is defined as the *set of digital workplace tools and applications that enable knowledge workers to be more productive*.

In Romania, Anghelache (1999-2016) elaborated a broad analysis of Romania's economic and social evolution.

Regarding the level of internet use worldwide, in 2021 International Telecommunication Union (ITU) created the study "Measuring digital development". According to this study, 4.9 billion people were using the Internet in 2021, that means around 63% of the world's population is now online, with almost 17% more people than 2019 (ITU, 2021).

In 2021, Romania ranks 30th out of 36 countries (27 European Union countries, countries seeking to join the EU) on the indicator Computer and internet use by employees, with 38% of users out of the total employed population. The first place is held by Finland with 85% and Sweden with Norway in second place with 83% of users in the total employed population (EUROSTAT).

2. Exploratory analysis- effects of computer and internet use by employees on the labour productivity in Romania

In this analysis we have used indicators taken from the database of the Romanian National Institute of Statistics and Eurostat - the European Commission's department responsible for publishing comparable statistics for the whole of the EU. The service consolidates data collected by national authorities and harmonises them to ensure that each indicator - for example the value of unemployment - is calculated in the same way in all Member States.

In the table below (Table 1), for each indicator we have mentioned its name, definition (according to INSS and Eurostat), unit of measurement and notation used in the analysis. All indicators considered are reported annually.

Table 1. Indicators used in the analysis

Indicator	Notation	Definition
Labour productivity, per person employed, by economic activity (Lei/person)		The employed population comprises all persons - both employees and self-employed - engaged in production activities that fall within the limits of national accounts production. Labour productivity per person employed was calculated as the ratio of gross value added to the number of persons employed. Hourly labour productivity was calculated as the ratio of gross value added to the number of hours worked. Unit of measurement: RON/person.
Agriculture, forestry and fisheries	RO_AGR	
Mining and quarrying; manufacturing; electricity, gas, heat, hot water and air conditioning supply; waste, remediation activities	RO_IND	
Construction	RO_CON	
Wholesale and retail trade; repair of motor vehicles and motorcycles; transportation and storage; hotels and restaurants	RO_CU	
Information and communication	RO_INF	
Financial intermediation and insurance	RO_INT	
Real estate trading	RO_TRA	
Professional, scientific and technical activities; administrative and support service activities	RO_PROF	
Public administration and defense; public social security; education; health and social work activities	RO_PUB	
Entertainment, cultural and recreation activities; repair of household goods and other service activities	RO_DE	
Computer and internet use by employees	UCI	

		time on the main variables and looking in more depth at other aspects at a specific point in time. Unit of measurement: percentage of total employed population.
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The table below (Table 2) shows the main numerical characteristics of the variables considered in the analysis. The following data are included in this table:

- number of observations
- mean
- standard deviation of variation.

Table 2. Descriptive Statistics

	Mean	Std. Deviation	Analysis N
RO_AGR	16600.00	4682.970	9
RO_IND	103356.33	13381.037	9
RO_CON	73774.89	10021.555	9
RO_CU	74941.56	17328.752	9
RO_INF	255273.44	62333.583	9
RO_INT	196444.67	29569.497	9
RO_TRA	2352147.67	465738.419	9
RO_PROF	152770.67	38046.246	9
RO_PUB	88407.56	29256.351	9
RO_DE	102070.56	21725.456	9
UCI	30.33	2.958	9

Source: Table processed in the SPSS programme

The correlation matrix is shown in Table 3 and indicates the significant links between the variables analyzed (Pintilescu, C.2017).

There is a positive relationship between the labour productivity of employees in each industry of the economy and the use of computers and internet by employees (UCI) - in the sense that when the score for each industry increases, the score for the use of computers also increases.

Table 3. Correlation Matrix^{a,b}

Corelația	RO_A GR	RO_I ND	RO_CON	RO_C U	RO_IN F	RO_I NT	RO_T RA	RO_PR OF	RO_PUB	RO_D E	UCI
RO_AGR	1.000	.993	.774	.968	.961	.292	.888	.989	.968	.925	.859
RO_IND	-	1.000	.759	.973	.955	.322	.861	.993	.964	.933	.881
RO_CON	-	-	1.000	.711	.866	-.013	.490	.748	.862	.686	.601
RO_CU	-	-	-	1.000	.895	.237	.888	.965	.931	.961	.822

RO_INF	-	-	-	-	1.000	.256	.755	.954	.968	.837	.786
RO_INT	-	-	-	-	-	1.000	.127	.322	.174	.263	.220
RO_TRA	-	-	-	-	-	-	1.000	.862	.806	.833	.806
RO_PROF	-	-	-	-	-	-	-	1.000	.945	.932	.869
RO_PUB	-	-	-	-	-	-	-	-	1.000	.898	.830
RO_DE	-	-	-	-	-	-	-	-	-	1.000	.803
UCI	.859	.881	.601	.822	.786	.220	.806	.869	.830	.803	1.000

a. Determinant = .000

b. This matrix is not positive definite.

Source: Table processed in the SPSS programme

According to the Correlation Matrix table, the results of the correlation coefficients indicate strong positive relationships between each branch of the economy and computer use (UCI), thus resulting in strong positive relationships between:

- computer use (UCI) and RO_AGR = 0.859
- computer use (UCI) and RO_IND = 0.881
- computer usage (UCI) I RO_CU = 0.822
- computer usage (UCI) and RO_TRA = 0.806
- computer usage (UCI) and RO_PROF = 0.869
- computer usage (UCI) and RO_PUB = 0.830
- computer usage (UCI) and RO_DE = 0.803

The results indicate strong positive relationships between each economic domain and computer usage (UCI). When the score for each industry increases, for example: AGR, IND, CU, TRA, PROF, PUB, DE, the score for computer usage (UCI) will also increase.

It is also observed that the labour productivity of employees in the Financial intermediation and insurance branch (RO_INT) is the only one not associated with computer use (UCI), there is no link between the two variables analysed.

The values of the variances in Table 4: after factor extraction are calculated based on the results from the output of the Component Matrix (Table 5) and the highest value was obtained at RO_IND=0.996 and the lowest value was calculated at RO_CON=0.747, followed by RO_TRA=0.761.

Table 4. Communalities

	Initial	Extraction
RO_AGR	1.000	.993
RO_IND	1.000	.996
RO_CON	1.000	.747
RO_CU	1.000	.947
RO_INF	1.000	.919
RO_INT	1.000	.954
RO_TRA	1.000	.761
RO_PROF	1.000	.985
RO_PUB	1.000	.965

RO_DE	1.000	.887
UCI	1.000	.775

Extraction Method: Principal Component Analysis. (Source: Table processed in the SPSS programme)

The eigenvalues associated with each factor axis and the variance explained by each factor axis are shown in the Total Variance Explained output, Initial Eigenvalues column where the correlation matrix eigenvalues are:

$\lambda_1 = 8.895$	$\lambda_7 = 0.030$
$\lambda_2 = 1.035$	$\lambda_8 = 0.022$
$\lambda_3 = 0.595$	$\lambda_9 = 1.168E-016$
$\lambda_4 = 0.234$	$\lambda_{10} = -2.713E-016$
$\lambda_5 = 0.143$	$\lambda_{11} = -4.914E-016$
$\lambda_6 = 0.047$	

The values of own λ_k correspond to the inertias explained on the factor axes. Their sum is the total inertia of the point cloud equal to the number of statistical variables in the initial data table, the sum of the elements of the main diagonal of the correlation matrix.

The first two factor axes together explain 90.266% of the total variance (Total Variance Explained output, Cumulative % column).

Table 5. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.895	80.859	80.859	8.895	80.859	80.859
2	1.035	9.407	90.266	1.035	9.407	90.266
3	.595	5.413	95.680			
4	.234	2.126	97.806			
5	.143	1.299	99.105			
6	.047	.425	99.530			
7	.030	.270	99.799			
8	.022	.201	100.000			
9	1.168E-016	1.062E-015	100.000			
10	-2.713E-016	-2.467E-015	100.000			
11	-4.914E-016	-4.467E-015	100.000			

Extraction Method: Principal Component Analysis.

Source: Table processed in the SPSS programme

The Total column in Table 5 shows the values in absolute form and the % Variance column is in relative form, i.e. percentages of total inertia (Pintilescu, C.2017):

$$\sum_{k=1}^k \lambda_k = In$$

where:

In is the total inertia of the point cloud.

According to the values in Table 5 we obtain:

$$\sum_{k=1}^k \lambda_k = 8.895 + 1.035 = 9.93$$

The variance explained by each factor axis (Total Variance Explained output - % of Variance column) is calculated according to the following relationship:

$$\% \text{ Variance} = \lambda_k / In$$

For Table 5, the first factor axis explains $8.895/9.93=0.8085$ (80.85%) of the total variance of the point cloud. The second factor axis explains 9.407% of the total variance of the point cloud

The number of factor axes to be interpreted in the PCA is chosen according to several criteria:

- Kaiser's (1960) criterion involves choosing that number of factor axes for which the corresponding eigenvalues are greater than one.

For the example shown in the output of Table 5, according to this criterion a factor axis corresponding to a single eigenvalue ($\lambda_1=8.895$) >1 is chosen.

- Cattell's (1966) criterion is to plot the eigenvalues (Scree Plot) and to follow a sharp decrease in inertia explained by them. Select the axes that precede this sudden change in the slope of the eigenvalue plot.

The plot shown in Figure 1 shows that a single factor axis is chosen for interpretation, showing the largest differences between the statistical units in terms of the variables considered. It can be seen that there are large differences in magnitude between the first two own values and the other two values.

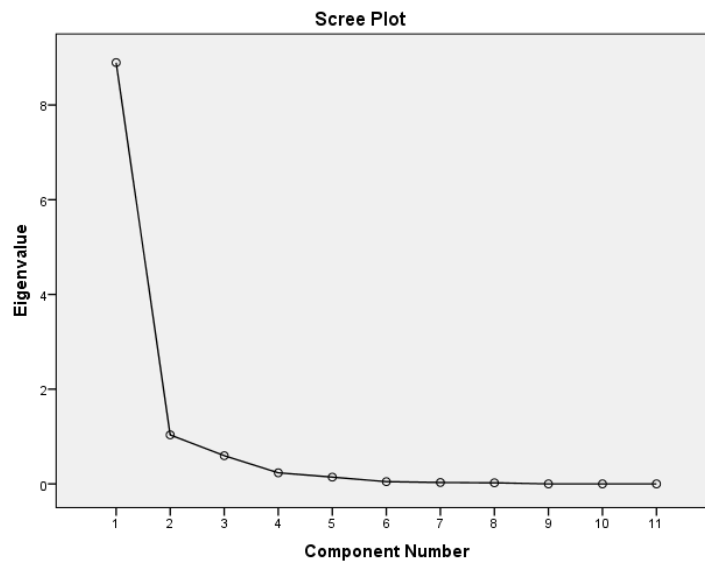


Figure 1. Graphical representation of the eigenvalues of the correlation matrix (Source: Table processed in the SPSS programme)

The coordinates of the variables on the factor axes show the value of the correlation coefficients between the variables X_j and the respective factor axis. It is determined according to the relation:

$$G_{k(j)} = \sqrt{\lambda_k} \cdot u_{kj}$$

where:

λ_k = is the eigenvalue corresponding to the factor axis k

u_{kj} = the coordinates of the eigenvector associated with the eigenvalue λ_k .

The coordinate values of the variables are shown in the Component Matrix output (Table 6) and show the position of the variables on the factor axes. In this representation, the variables RO_AGR and RO_IND have a high positive coordinate (close to 1) on the first factor axis (0.996) and positive coordinates also on the second factor axis (0.025) RO_AGR and (0.061) RO_IND. This shows that the two variables will be plotted in the positive value quadrant of both factor axes.

The variables RO_CON, RO_INF, RO_TRA and RO_PUB have positive coordinates on the first factor axis (0.789, 0.957, 0.872 and 0.975) and negative coordinates on the second factor axis (-0.353, -0.048, -0.024 and -0.121). This shows that the four variables will be plotted in the quadrant of positive values on the first factor axis and in the quadrant of negative values on the second factor axis.

We have no variables with negative coordinates on both factor axes in Table 6.

Table 6. Component Matrix^a

	Component	
	1	2
RO_AGR	.996	.025
RO_IND	.996	.061

RO_CON	.789	-.353
RO_CU	.973	.002
RO_INF	.957	-.048
RO_INT	.268	.939
RO_TRA	.872	-.024
RO_PROF	.990	.066
RO_PUB	.975	-.121
RO_DE	.941	.037
UCI	.880	.026

Extraction Method: Principal Component Analysis.

a. 2 components extracted.

Source: Table processed in the SPSS programme

The analysis of the position of the variables on the first factor axis in Figure 2 shows that there is a strong link between the use of computers and internet by employees (UCI) and the branches of the economy, especially RO_AGR and RO_TRANS, which in the period 2012-2020 have considerably improved the use of technology in carrying out activities.

The labour productivity of employees in the economic activity RO_INT (Financial intermediation and insurance) shows the lowest relation to the use of computers and internet by employees (UCI) in the period 2012-2020- the degree of technology use is similar to previous years, there were no significant changes in productivity growth influenced by technology.

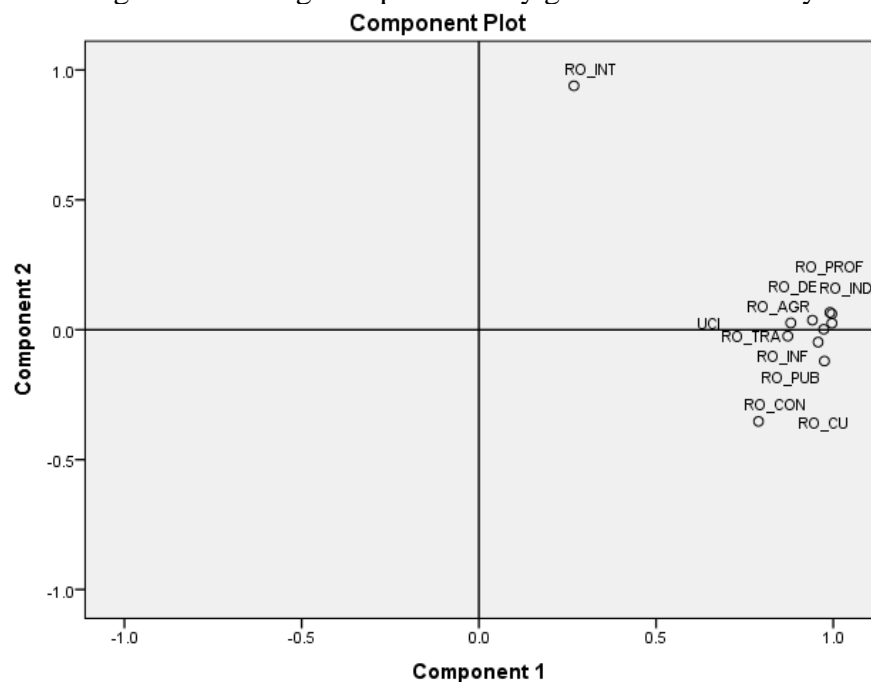


Figure 2. Representation of the variable points of the first two factor axes (Source: Table processed in the SPSS programme)

The Component Score Coefficient Matrix shows the values of the contributions of the variables to the inertia of the factor axes and are presented in the output below.

Table 7. Component Score Coefficient Matrix

	Component	
	1	2
RO_AGR	.112	.024
RO_IND	.112	.059
RO_CON	.089	-.341
RO_CU	.109	.002
RO_INF	.108	-.046
RO_INT	.030	.908
RO_TRA	.098	-.024
RO_PROF	.111	.064
RO_PUB	.110	-.117
RO_DE	.106	.036
UCI	.099	.025

Extraction Method: Principal Component Analysis. Component Scores. (Source: Table processed in the SPSS programme)

High values indicate the significant importance of the respective variable. In Table 7, the highest value (0.112) is recorded by RO_AGR and RO_IND, followed by RO_PROF with a value of 0.111.

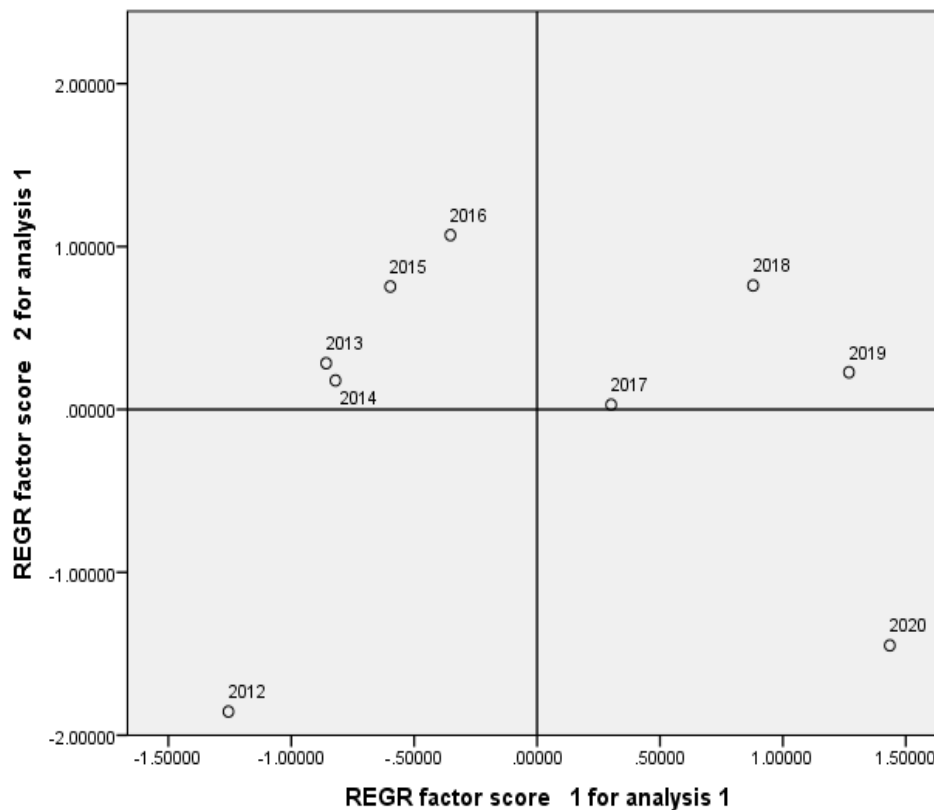


Figure 3. Graphical representation of statistical units in the system of the first two factor axes (Source: Table processed in the SPSS programme)

The statistical units plotted in the previous diagram show that the statistical units 2013, 2014, 2015, 2016 have negative coordinates on the first factor axis and are similar. Units 2017, 2018, 2019 have positive coordinates on this axis and are more different.

The year 2020 is different from the other years, influenced also by a considerable decrease in labour productivity of employees in two sectors: RO_DE (Entertainment, cultural and recreational activities; repair of household goods and other services) with 13,803.03 lei/person and RO_INT (Financial intermediation and insurance) with 46,870.8 lei/person.

3. Conclusions

Powerful new technologies are increasing productivity, improving lives, and reshaping our world (McKinsey Global Institute, 2017).

The link between labour productivity and the use of computers and the internet - is manifested differently in different sectors of the Romanian economy in the period 2012-2020.

The correlation between computer/internet use coefficients and labour productivity was strongly positive within economic sectors, mainly: Agriculture, forestry and fisheries (RO_AGR) and Mining and quarrying; manufacturing; electricity, gas, heat, hot water and air conditioning supply; waste, remediation activities (RO_IND).

In the future we would like to analyse the labour productivity on different economic sectors and technology/digitalisation from 4-5 countries, to study the effects of this indicators and economic growth.

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