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THE DIGITAL TRANSFORMATION LANDSCAPE: A COMPARATIVE AND CORRELATION ANALYSIS AMONG THE EUROPEAN UNION COUNTRIES

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ABSTRACT

In a world of constant expansion and rapid changes, data is the most powerful instrument fororganizations to thrive. Vast amounts of data although represent a challenge itself when lacks asolid foundation to set the premises of a digital oriented organization. Since 2020, when the entiremappemonde confronted the pandemic, the necessity for digitalization was never more acute.Digitalization gained momentum ever since and advantages, inconveniencies and limitations aredisputed in both academic and business environment. We are now assisting to a 5th revolutionconsisting in proliferation of Artificial Intelligence as the processor of immense data quantities. This article aims to expose in the first part a conceptual definition of the terms "digitization","digitalization" and "digital transformation "and what is the correlation between them. In thesecond part, are detailed the benefits and concerns associated with the digital transformation from an economic, labor and business environment perspective. Lastly, the analysis of the digitalizationand digital transformation level of the European Union countries from an enterprise outlook.

Keywords: Digitalization, Digital Transformation, Technology Adoption

JEL: M31, F00, L20

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1. INTRODUCTION

Digital Transformation stands on the forefront of governments, organizations and business entities agenda, aiming to revolutionize the world as we know it across all sectors. In this direction,with an allocated budget of 7,9 billion euros, European Union has launched Digital Europe Programme, that “aims to accelerate economic recovery and drive digital transformation”. In 2020,the pandemic set the favorable context for digital transformation and digitalization to become an utmost priority and to be accelerated to an unprecedented extent.

McKinsey defines digital transformation as the rewiring of an organization, with the goal of creating value by continuously deploying technology at scale. In parallel, Forrester states that it means applying the right technologies to create or update internal processes or customer experiences that rise to the changing business demands and new customer requirements. Another analyst, IDC, describes it as the approach by which enterprises drive changes in their business models and ecosystems by leveraging digital competencies.

Among the various definitions circulating, there is not a generally accepted one. In a study developed by Vial (2019) he finds that the definitions reviewed are distinctive in regards to the types of technologies and the nature of transformation. Additionally, they primarily relate to organizations. Hence, he proposes the following definition: “Digital Transformation is defined asa process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies.”

Reevaluating from a narrower perspective, digital transformation represents the crystalized version of digitalization, respectively digitization. The three concepts are interrelated in a hierarchical sequence. According to Gartner, the concept of digitalization refers to the steps of moving to a digital business using digital technologies to change a business model and provide new revenue and value-producing opportunities.

While digitalization focuses mainly on converting the *processes* from analog to digital, digitization translates analog information and data into digital form—for example, scanning a photo or document and storing it on a computer (Accenture). Consequently, digitization concentrates on converting *data* from analog to digital format, to further enable the processes for the digital change.

Over the years the increasing amounts of data made impossible the storing, analyzing and processing, which created the necessity of a simpler way of managing these volumes of data. Digitization came towards this need, setting the foundations of the digitalization and digital transformation by transitioning the data from analog signal to a digital signal through an analog-to-digital converter.

Figure 1 – Techtarget.com, accessed on August 2024

The common scope of these three concepts is unquestionably the progression of the organizations towards enhanced quality and efficiency of the real economy, summarizing mechanisms such as "cost reduction," "efficiency enhancement," and "innovation strengthening" (Liu et al, 2024).

2. The Implications, Benefits and Concerns of Digitalization andDigital Transformation

At an organization level, particularly on the operation model, some of the implications can be identified in Vial's visualization of the digital transformation building blocks. Disruption across consumer behavior and competition, triggers changes in the way organizations operate and create their value. Additionally, barriers are given by resistance and inertia or security and privacy concerns.

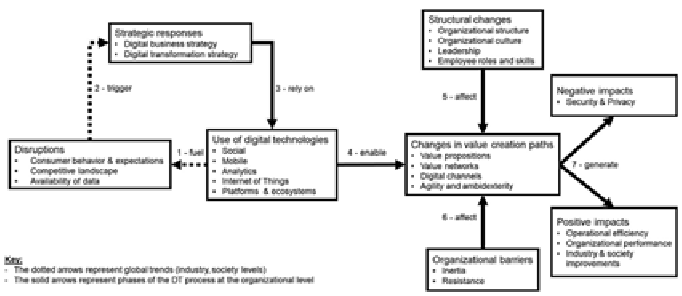

Figure 2 – Building blocks of the DT process

There are myriads of implications in digital transformation across various areas such as economy,education and labor, or business environment. Looking from a high-level perspective (Fig. 3), thegreatest digitalized sectors, where the labor, usage of technology and assets are predominantly impacted are IT, Media, Processional Services and Finance. On the opposite pole there is Hospitality, Construction and Agriculture.

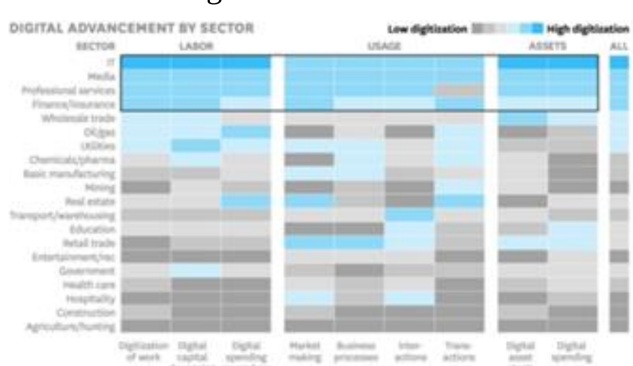

Figure 3 Digitalization across sectors (Bieliaieva et al. 2021)

We can observe a massive discrepancy between the first mentioned sectors and the latter ones. Yet, according to Bieliaieva (et al, 2021) the industries with the highest indicators in terms of GDP and employment are the least "digitized".

Therefore, arises the question what benefits the digitalization and digital transformation bring for the organizations that went through a transformation process and what are the concerns associated. In the table below, we have extracted from several sources the main benefits and concerns linked with digital transformation from an economy, labor and business environment perspective.

There are identified four key positive elements in digital transformation: risk reduction, cost optimization, customer experience enhancement and revenue and productivity growth. On the negative side, job security, complexity and cybersecurity represent the main points of concern.

	Benefits	**Concerns**	**Source**
Economy	• Boost productivity • Smooths public sector services such as Education, Healthcare, Public Services • Bridge geographical gaps Contributes at economic growth • Foster Innovation • Resource Optimization	• Cybersecurity • Privacy	Staiculescu, 2024
Labor	• Remote and flexible work, including part-time jobs, temporary and self-employment • Increased productivity and creativity • Automatization of repetitive task • Arising of new job roles or transforming roles	• Jobs closure • Interdependency between labor digitalization and development, economy and education level of the country • Inequality between new job roles transformation and new professions • Reduced demand for labor in enterprises	Matei et al, 2023 Pedchenko et al, 2021 Yuhong Huang, 2024
Business Environment	• Cost optimization • Drive growth • Improve time to market • Improve product and service quality • Lower risks • Drive sustainability • Improve customer experience	• Complexity given by sophisticated technology • Budget limitations • Workforce reluctance to new • Cybersecurity	ptc.com stefanini.com

3. METHODOLOGY

We have used a Canonical Correlation Analysis to investigate the link between a dependent variable (GDP/capita) and five independent variables.

The chosen variables were as follows:

desi_bigdata = represents the comprehensive infrastructure and tools needed to build and maintain robust, scalable, and efficient data pipelines capable of handling real-time and batch processing of massive datasets. It ensures that data flows seamlessly from ingestion to storage and analysis, supporting various business and analytical needs;

desi_dps_biz_national = stands for "Digital Public Services for Businesses.";

desi_einv_sm = represents a comprehensive, scalable, and automated solution for electronic invoicing, integrated within a real-time data streaming infrastructure. It ensures compliance, enhances efficiency, reduces costs, and provides valuable insights while maintaining high standards of data security and integrity;

desi_sme_esell = index refering to small and medium enterprises electronic selling; **desi_sme_esell_**eu = index refering to small and medium enterprises cross border electronic selling.

The analysis was done for EU and other 5 countries (EU, Romania, Slovakia, Lituania, Nederalnd, Malta).

The analysis was carried on following the steps:

- Define the independent and dependent variables
- Combine the data in to matrix
- Convert data into standard normal
- Generate the correlation matix
- Find the eigen values
- Calculate the canonical correlation.

The code used is as follows:

```
Calculating cannonical correlation
library(foreign) library(ggplot2)

import data set
setwd("C:/Users/mihai/OneDrive/Documents/2024/PhD/Articol Diana Dinu/Prelucrare R CCA")

read data df=data set
df <- read.csv("Date_R.csv", header = TRUE, sep = ",")df
define independent variables
X1_EU <- df[,3] X2_EU <- df[,4] X3_EU <- df[,5] X4_EU <- df[,6] X5_EU <- df[,7] X1_RO <-
df[,9] X2_RO <- df[,10] X3_RO <- df[,11] X4_RO <- df[,12] X5_RO <- df[,13]X1_SK <- df[,15]
X2_SK <- df[,16] X3_SK <- df[,17] X4_SK <- df[,18] X5_SK <- df[,19]X1_LT <- df[,21] X2_LT
<- df[,22] X3_LT <- df[,23] X4_LT <- df[,24] X5_LT <- df[,25]
X1_NL <- df[,33] X2_NL <- df[,10] X3_NL <- df[,11] X4_NL <- df[,12] X5_NL <- df[,13] X1_MT <-
df[,39] X2_MT <- df[,10] X3_MT <- df[,11] X4_MT <- df[,12] X5_MT <- df[,13]
define dependent variables
Y1_EU <- df[,2] Y1_RO <- df[,8] Y1_SK <- df[,14] Y1_LT <- df[,20] Y1_NL <- df[,32] Y1_MT
<- df[,38]

combining independent variables
EU_i <- cbind(X1_EU, X2_EU, X3_EU, X4_EU, X5_EU) dim(EU_i) EU_iRO_i
<- cbind(X1_RO, X2_RO, X3_RO, X4_RO, X5_RO)
```

```
SK_i <- cbind(X1_SK, X2_SK, X3_SK, X4_SK, X5_SK) LT_i
<- cbind(X1_LT, X2_LT, X3_LT, X4_LT, X5_LT) NL_i <-
cbind(X1_NL, X2_NL, X3_NL, X4_NL, X5_NL) MT_i <-
cbind(X1_MT, X2_MT, X3_MT, X4_MT, X5_MT)
#combining dependent variables EU_d <- cbind(Y1_EU) dim(EU_d) EU_dRO_d
<- cbind(Y1_RO)
SK_d   <-   cbind(Y1_SK)
LT_d   <-   cbind(Y1_LT)
NL_d   <-   cbind(Y1_NL)
MT_d <- cbind(Y1_MT)
standardized dependent and independent variable
x.std_EU <- sweep(EU_i, 2, sqrt(apply(EU_i, 2, var)), FUN="/") x.std_EU y.std_EU <-
sweep(EU_d, 2, sqrt(apply(EU_d, 2, var)), FUN="/") y.std_EUx.std_RO <- sweep(RO_i,
2, sqrt(apply(RO_i, 2, var)), FUN="/") x.std_RO y.std_RO <- sweep(RO_d, 2,
sqrt(apply(RO_d, 2, var)), FUN="/") y.std_ROx.std_SK <- sweep(SK_i, 2,
sqrt(apply(SK_i, 2, var)), FUN="/") x.std_SK y.std_SK <- sweep(SK_d, 2,
sqrt(apply(SK_d, 2, var)), FUN="/") y.std_SK
x.std_LT <- sweep(LT_i, 2, sqrt(apply(LT_i, 2, var)), FUN="/") x.std_LT y.std_LT <-
sweep(LT_d, 2, sqrt(apply(LT_d, 2, var)), FUN="/") y.std_LT x.std_NL <- sweep(NL_i,
2, sqrt(apply(NL_i, 2, var)), FUN="/") x.std_NL y.std_NL <- sweep(NL_d, 2,
sqrt(apply(NL_d, 2, var)), FUN="/") y.std_NL x.std_MT <- sweep(MT_i, 2,
sqrt(apply(MT_i, 2, var)), FUN="/") x.std_MT y.std_MT <- sweep(MT_d, 2,
sqrt(apply(MT_d, 2, var)), FUN="/") y.std_MT
block of correlation matrix
R11_EU      <-   cor(x.std_EU)   R11_EU   R22_EU   <-   cor(y.std_EU)   R22_EU   R12_EU
            <-cor(x.std_EU, y.std_EU) R12_EU R21_EU <- t(R12_EU) R21_EU

R11_RO <- cor(x.std_RO) R11_RO R22_RO <- cor(y.std_RO) R22_RO R12_RO <-cor(x.std_RO,
y.std_RO) R12_RO R21_RO <- t(R12_RO) R21_RO

R11_SK <- cor(x.std_SK) R11_SK R22_SK <- cor(y.std_SK) R22_SK R12_SK <- cor(x.std_SK,
y.std_SK) R12_SK R21_SK <- t(R12_SK) R21_SK

R11_LT <- cor(x.std_LT) R11_LT R22_LT <- cor(y.std_LT) R22_LT R12_LT <- cor(x.std_LT,
y.std_LT) R12_LT R21_LT <- t(R12_LT) R21_LT

R11_NL   <-   cor(x.std_NL)        R11_NL   R22_NL   <-   cor(y.std_NL)        R22_NL R12_NL <-
cor(x.std_NL, y.std_NL) R12_NL R21_NL <- t(R12_NL) R21_NL

R11_MT <- cor(x.std_MT) R11_MT R22_MT <- cor(y.std_MT) R22_MT R12_MT <-cor(x.std_MT,
y.std_MT) R12_MT R21_MT <- t(R12_MT) R21_MT

finding E1 and E2 matrix
E1_EU <- solve(R11_EU)%%(R12_EU)%%solve(R22_EU)%%(R21_EU) E1_EU E2_EU <-
solve(R22_EU)%%(R21_EU)%%solve(R11_EU)%%(R12_EU) E2_EU

E1_RO <- solve(R11_RO)%%(R12_RO)%%solve(R22_RO)%%(R21_RO) E1_RO E2_RO <-
solve(R22_RO)%%(R21_RO)%%solve(R11_RO)%%(R12_RO) E2_RO

E1_SK <- solve(R11_SK)%%(R12_SK)%%solve(R22_SK)%%(R21_SK) E1_SK E2_SK <-
solve(R22_SK)%%(R21_SK)%%solve(R11_SK)%%(R12_SK) E2_SK
```

E1_LT <- solve(R11_LT)%%(R12_LT)%%solve(R22_LT)%%(R21_LT) E1_LT E2_LT <- solve(R22_LT)%%(R21_LT)%%solve(R11_LT)%%(R12_LT) E2_LT

E1_NL <- solve(R11_NL)%%(R12_NL)%%solve(R22_NL)%%(R21_NL) E1_NL E2_NL <- solve(R22_NL)%%(R21_NL)%%solve(R11_NL)%%(R12_NL) E2_NL

E1_MT <- solve(R11_MT)%%(R12_MT)%%solve(R22_MT)%%(R21_MT) E1_MT E2_MT <- solve(R22_MT)%%(R21_MT)%%solve(R11_MT)%%(R12_MT) E2_MT

finding eigen values eigen(E1_EU)
eigen(E2_EU)

eigen(E1_RO) eigen(E2_RO)
eigen(E1_SK) eigen(E2_SK)
eigen(E1_LT) eigen(E2_LT)
eigen(E1_NL) eigen(E2_NL)
eigen(E1_MT) eigen(E2_MT)
Result / Output
canonical correlation
cannon.corr_EU <- sqrt(eigen(E1_EU)$values) cannon.corr_EU
cannon.corr_RO <- sqrt(eigen(E1_RO)$values) cannon.corr_RO
cannon.corr_SK <- sqrt(eigen(E1_SK)$values) cannon.corr_SK
cannon.corr_LT <- sqrt(eigen(E1_LT)$values) cannon.corr_LT
cannon.corr_NL <- sqrt(eigen(E1_NL)$values) cannon.corr_NL
cannon.corr_MT <- sqrt(eigen(E1_MT)$values) cannon.corr_MT

The results are shown in the following chapter.

4. RESULTS

An important finding is that the GDP/capita is strongly linked to big data, with a correlation index very close to 1, and not at all or almost not at all linked to Digital Public Services for Businesses, e-invoicing, electronic sales (domestic and cross-border).

The results are shown in the following table:

	desi_bigdata	**desi_dps_biz_national**	**desi_einv_sm**	**desi_sme_esell**	**desi_sme_esell_eu**
EU	9.98E-01	0	1.68E-08	1.13E-08	1.13E-08
RO	9.97E-01	1.77E-09	1.77E-09	2.05E-09	2.05E-09
SK	1.00E+00	NaN	NaN	6.20E-09	1.39E-09
LT	9.52E-01	NaN	1.92E-09	NaN	0.00E+00
NL	9.90E-01	NaN	2.66E-09	NaN	NaN
MT	9.44E-01	2.96E-09	NaN	2.63E-09	0.00E+00

5. CONSLUSION

One of the important findings is that the GDP/capita is strongly linked to the infrastructure, implementations and usage of big data, and it is almost not linked at all to Digital Public Services for Businesses, to e-invoicing or to electronic sales (domestic or cross border).

The link of GDP/capita to big data is supporting the industrial revolution model proposed by KlausSchwab (2016). Big data is considered part of the fourth industrial revolution and partially is a consequence of the availability of cheap and largely spread sensors. The development and proliferation of the AI based systems should be considered as part of a fifth industrial revolution, and was generated by the need to process the generated data and the big data populations, which are difficult to process using classic algorithms. The other part of the fifth industrial revolution is related to the shift towards clean and renewable energy, which is not in discussion here.

The digitalization process has become first the companion of the humanity, and it is slowly evolving towards a genuine backbone.

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