The Impact and Correlation of the Digital Transformation on GDP Growth in Different Regions Worldwide

Javier Parra(✉), María E. Pérez-Pons, and Jorge González

Grupo de Investigación BISITE, Universidad de Salamanca, Salamanca, Spain
{javierparra, eugenia.perez, jorgegonzalez}@usal.es

Abstract. Currently our society is experiencing a process of digital transformation worldwide, in 2016 the digital economy accounted for 22.5% of the world economy. The digital transformation has enabled the creation of new business models, the generation of opportunities and the maximization of efficiency in traditional companies that have wanted to reconvert their business model towards a new digital environment and the culture of data orientation. This document contains an analysis of how the adoption of digital technologies has a positive influence on the growth of the world economy as a whole, and particularly on the growth of some regions of the world.

Keywords: Digital transformation · Growth · Technology convergence first section

1 Introduction

Native digital companies have responded best to the digital transformation [1], maximizing profits and being more efficient with the new business models that have appeared in recent years [2, 3]. Despite the possibilities of interconnection that technological and digital advances allow, the digital transformation has not spread uniformly throughout the world, nor has it caused the same effects in all countries equally, as some have benefited more than others. One of the main reasons for this inequality is called the digital divide. The difference in access to the use of technology is called the digital divide, and it focuses particularly on the conditions and differences in access to the Internet [4] between different countries in the world. Due to the possibilities offered by the digital transformation and the differences between countries in terms of its implementation, at the last G20 summit, the digital transformation is an issue that has been included in the global agenda. It is expected to lead to more inclusive and sustainable prosperity for all countries in the world [5]. The fact that less digitally developed areas are missing out on the new capabilities offered by computing as well as, for example, artificial intelligence techniques that optimize industrial processes [6]. On the other hand, also techniques for reducing electricity consumption from which areas with fewer energy resources could benefit [7]. The reasons mentioned above, which have an international impact, lead us to analyze the inequality that exists around the benefits derived from the digital transformation in different parts of the world. To

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this end, we will try to analyze the relationship between GDP and the digital adoption rate (DAI) in each continent.

2 Data and Methodology

This section analyses the relationship between GDP and the digital adoption rate (DAI), adding a GDP delay to its value in t−2. It will be analyzed whether there is a significant relationship between both variables and how this relationship is expressed on each continent. This study will allow us to visualize the effects that digital adoption has on each continent and how investment in digital adoption does not affect the growth of each region in the same way. The data for the study was obtained from the World Bank's database for both GDP and IAD. To show a better understanding of the study we will define the digital adoption rate (DAI). The Digital Adoption Index (DAI) is an index created by the World Bank to measure the adoption rate of technology in countries around the world. This index was introduced in "World Development Report 2016: Digital Dividends". What the authors pointed out in this report is that despite the great technological expansion that exists around the world, there is also great inequality in different areas [4]. The areas mentioned above are the benefits of technology, the quality of employment, and the ability of countries to participate in the global economy. In the case of this study, the model described below focuses on studying the benefits obtained through their influence on each country's GDP at the global level. GDP data are measured in 2010 $ while data on the digital adoption rate are measured in 100 although they are usually measured in 1. Because of these differences, logarithms have been used in estimating the model. On the other hand, the digital adoption rate provides data for 178 countries, but due to lack of information we have had to eliminate Venezuela and Syria, so we are left with a total of 176 countries analyzed which we will group by continent. To analyze the relationship, we have defined a panel data model with fixed effects that can be defined as in Eq. (1):

$$\log\left(PIB_{i,t}\right) = \beta_1 \ \log\left(PIB_{i,t-2}\right) + \beta_2\left(DAI_{i,t}\right) + \varepsilon_{i,t} \tag{1}$$

Where $PIBi$, t represents the GDP of country i in year t, $PIBi$, $t-2$ represents the GDP of country i in year t−2, and $DAIi$, t represents the digital adoption rate (DAI) for country i in year t. We have considered only two time periods, t = 2014 and t = 2016, which are for which we have obtained the data.

The estimated model is a log-log model where an x% increase in one of the explanatory variables that are statistically significant implies an x% increase in the explained variable (ceteris paribus).

3 Results

The different results are detailed below. First, the entire data set has been analyzed, and then the sample has been categorized and classified by continent. For the dataset of all countries in the world (Code 1), the IAD has a coefficient of 0.36 and $\boldsymbol{PIB_{t-2}}$ has a coefficient of 0.23. This means that a 1% increase in IAD for all countries combined would imply a 0.36% increase in $\boldsymbol{PIB_t}$ for all countries combined. Both variables are statistically significant at 5%, but the value of $\boldsymbol{R^2}$ is nevertheless small ($\boldsymbol{R^2} = \mathbf{0,\ 40}$). Although there is a relationship between the variables, $\boldsymbol{R^2}$ indicates that there is a great dispersion in the data, and this may be due to the fact that there are great differences between the level of development of the different countries in the world. In obtaining these results on the levels of dispersion, we will study the results distinguishing by continents (Fig. 1).

```
> grun.dosvar <- plm(log(pib)~log(dai)+log(piban), data = DA)
> summary(grun.dosvar)
Oneway (individual) effect Within Model

Call:
plm(formula = log(pib) ~ log(dai) + log(piban), data = DA)

Balanced Panel: n = 176, T = 2, N = 352

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-0.160610 -0.015799  0.000000  0.015799  0.160610

Coefficients:
           Estimate Std. Error t-value  Pr(>|t|)
log(dai)   0.361565   0.058383  6.1930 4.129e-09 ***
log(piban) 0.225316   0.064507  3.4929 0.0006058 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    0.65361
Residual Sum of Squares: 0.39003
R-Squared:      0.40326
Adj. R-Squared: -0.20377
F-statistic: 58.7921 on 2 and 174 DF, p-value: < 2.22e-16
```

Fig. 1. (Code **1)** World model regression analysis. Source: Own elaboration with R Software

For Europe (Code 2), IAD has a coefficient of 0.25 and $\boldsymbol{PIB_{t-2}}$ has a coefficient of 0.85. An increase of 1% in ICD for all countries as a whole would imply an increase of 0.25% in $\boldsymbol{PIB_t}$ for Europe as a whole. Both variables are statistically significant at a significance level of 5% and, unlike the model for all countries in the world, $\boldsymbol{R^2}$ is higher ($\boldsymbol{R^2}$ = 0.59). What we observe is that in this case the dispersion of data is less, that the IAD has less influence than in the previous case and that $\boldsymbol{PIB_{t-2}}$ has more influence. This may be because European countries already enjoy high levels of IAD and there is not as strong an increase in IAD as in other regions of the world, which would explain a smaller effect in predicting their level of GDP (Fig. 2).

```
> modeleuropa <- plm(log(pib)~log(piban)+log(dai), data = europa)
> summary(modeleuropa)
Oneway (individual) effect Within Model

Call:
plm(formula = log(pib) ~ log(piban) + log(dai), data = europa)

Balanced Panel: n = 41, T = 2, N = 82

Residuals:
      Min.     1st Qu.      Median     3rd Qu.        Max.
-8.5972e-02 -9.5042e-03  3.2803e-15  9.5042e-03  8.5972e-02

Coefficients:
           Estimate Std. Error t-value  Pr(>|t|)
log(piban)  0.84743    0.16261  5.2113 6.417e-06 ***
log(dai)    0.24717    0.11311  2.1852   0.03495 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    0.10787
Residual Sum of Squares: 0.044121
R-Squared:      0.591
Adj. R-Squared: 0.15054
F-statistic: 28.1775 on 2 and 39 DF, p-value: 2.6827e-08
```

Fig. 2. (Code **2)** Europe model regression analysis. Source: Own elaboration with R Software

For the case of Asia (Code 3), we found that IAD is the only statistically significant variable at 5%. The value of its coefficient is 0.56 and the estimate has a $\boldsymbol{R^2}$ = 0.68, the highest in the study and the one that shows less dispersion of the data. This implies that an increase of 1% in IAD in Asian countries implies an increase of 0.56% in $\boldsymbol{PIB_t}$ for Asian countries. These results may be due to the fact that Asian countries, especially China, India and Indonesia, are experiencing high rates of economic growth combined with high rates of inclusion of technology among their population, which would make greater adoption of technology key to their growth (Fig. 3).

```
> modelasia <- plm(log(pib)~log(piban)+log(dai), data = asia)
> summary(modelasia)
Oneway (individual) effect Within Model

Call:
plm(formula = log(pib) ~ log(piban) + log(dai), data = asia)

Balanced Panel: n = 44, T = 2, N = 88

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-0.086438 -0.020466  0.000000  0.020466  0.086438

Coefficients:
           Estimate Std. Error t-value  Pr(>|t|)
log(piban) 0.083785   0.088743  0.9441    0.3505
log(dai)   0.557991   0.082915  6.7297 3.545e-08 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    0.20225
Residual Sum of Squares: 0.064912
R-Squared:      0.67905
Adj. R-Squared: 0.33518
F-statistic: 44.4309 on 2 and 42 DF, p-value: 4.3168e-11
```

Fig. 3. (Code **3)** Asian model regression analysis. Source: Own elaboration with R Software

In the case of the Americas (Code 4), the opposite is true of Asia. In this case, only $\boldsymbol{PIB_{t-2}}$ is statistically significant at 5%, and has a coefficient of 0.77. This means that an increase of 1% in $\boldsymbol{PIB_{t-2}}$ means an increase of $\boldsymbol{PIB_t}$ by 0.77%. $\boldsymbol{R^2}$ has a value of 0.61. In this case digital adoption would not be a statistically significant variable and therefore a variable that serves to predict ***PIB***, and its value would be determined by $\boldsymbol{PIB_{t-2}}$.

For the case of Africa (Code 5), none of the variables is statistically significant at 5% and in addition the value of $\boldsymbol{R^2}$ is a very low value, namely 0.18. What this indicates to us is that none of the variables that we have used in the study are statistically significant to predict $\boldsymbol{PIB_t}$ and furthermore there is a great dispersion in the data. This is because Africa is a country with the largest number of underdeveloped countries in the world where there are other factors that can be more decisive for its economic growth than the adoption of technology, such as an improvement in human capital or the health conditions of its population (Figs. 4 and 5).

```
> modelamerica <- plm(log(pib)~log(piban)+log(dai), data = america)
> summary(modelamerica)
Oneway (individual) effect Within Model

Call:
plm(formula = log(pib) ~ log(piban) + log(dai), data = america)

Balanced Panel: n = 34, T = 2, N = 68

Residuals:
      Min.     1st Qu.      Median     3rd Qu.        Max.
-5.4251e-02 -1.2270e-02 -3.1134e-15  1.2270e-02  5.4251e-02

Coefficients:
            Estimate Std. Error t-value  Pr(>|t|)
log(piban)  0.768875   0.151938  5.0604 1.667e-05 ***
log(dai)   -0.065026   0.111422 -0.5836    0.5636
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    0.066502
Residual Sum of Squares: 0.025963
R-Squared:      0.60959
Adj. R-Squared: 0.18257
F-statistic: 24.9821 on 2 and 32 DF, p-value: 2.9135e-07
```

Fig. 4. (Code **4)** Regression analysis American model. Source: Own elaboration with R Software

```
> modelafrica <- plm(log(pib)~log(piban)+log(dai), data = africa)
> summary(modelafrica)
Oneway (individual) effect Within Model

Call:
plm(formula = log(pib) ~ log(piban) + log(dai), data = africa)

Balanced Panel: n = 46, T = 2, N = 92

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-0.160691 -0.021819  0.000000  0.021819  0.160691

Coefficients:
           Estimate Std. Error t-value Pr(>|t|)
log(piban)  0.13851    0.13689  1.0119  0.31712
log(dai)    0.27882    0.15125  1.8434  0.07201 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    0.23574
Residual Sum of Squares: 0.1936
R-Squared:      0.17874
Adj. R-Squared: -0.69852
F-statistic: 4.78803 on 2 and 44 DF, p-value: 0.01314
```

Fig. 5. (Code **5**) Regression analysis African model. Source: Own elaboration with R Software

4 Conclusions

The adoption of technology has different impacts and contributes to growth in different ways depending on the region of the world being considered. In the model presented above, it can be seen how IAD is a statistically significant variable for economic growth globally as a whole (despite the wide dispersion of data), in Europe and Asia, it influences all regions positively. However, there are regions such as Africa and the Americas where it is not. As concluded in the “World Development Report 2016: Digital dividends”, not everyone has benefited equally from the expansion of technology around the world and the introduction of technology in companies, people and governments is not a measure that guarantees the economic growth of countries, and it is the inhabitants themselves who can develop strategies to promote digitalization in their countries as in the case of M-Pesa in Africa [8]. This study offers many lines of research, such as the study of the index by disaggregated components and how each one of them influences the growth of the different regions of the world. It could also be used to analyze similar models, but which include other variables such as human capital, expenditure on state GDP or expenditure on R&D.

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