Study Based on the Incidence of the Index of Economy and Digital Society (DESI) in the GDP of the Eurozone Economies

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Abstract. In the different developed societies, the different relationships between the so-called technological indicators and social development have been studied in the recent years. The aim of this work is to find a link between variables of the DESI (*digital economy and society index*) technology indicator and the GDP (*gross domestic product)* per capita for the current year. These relationships exist and are directly related to the use of certain services on the Internet by citizens and the integration of technology by companies.

Keywords: DESI · GDP · Technology · Digital transformation

1 Introduction

Over the past few years, companies in almost all industries have undertaken a number of initiatives to develop new digital technologies and explore the benefits of these [3]. The merger between the new digital technologies, called *Information and Communication Technologies (ICT),* and traditional industrial production has largely generated what we know today as Industry 4.0 [1]. The concept of Industry 4.0 has allowed, among other things, to transform factories into intelligent environments where information, objects, and people are connected thanks to the convergence between the physical and virtual worlds through cyber-physical systems [4]. The process that has allowed progress towards Industry 4.0 has focused on the technological change that has been experienced especially in advanced economies during the last decades from the twentieth century until today. In those years, a transformation has been achieved, mainly linked to scientific progress, which has allowed a significant decrease of technological capital prices [2]. Despite of the advances that have taken place in economies such as Germany and the United States, during the last two decades some countries of the European Union have not been able to take advantage of all the benefits that the so-called digital revolution has been offering. Although the onset of the crisis in 2008 led to a reduction in spending on research and development due to some austerity fiscal policies [7, 8] and a reduction in business investment, from 2014 the situation has changed considerably. Specifically, the digitalization of certain economies is beginning to act as a growth engine [5], and from 2015 onwards, in cases such as Spain, it has been responsible for up to 30% of value-added growth [10, 11].

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The digital transformation has not only been a growth engine in recent years in certain countries, such as Spain, but has also been a growth engine for the entire Eurozone. For this reason, the current work focuses on studying the relationship between the per capita GDP of the countries belonging to the Eurozone and the Digital Economy and Society Index (DESI) during the period 2015–2018.

1.1 The Digital Economy and Society Index (DESI)

The Digital Economy and Society Index (DESI) is an indicator that summarizes relevant indicators on Europe's digital performance and at the same time investigates the evolution of the European Union member states in terms of digital competitiveness. This index is produced annually by the European Commission [2]. The indicator in question is specifically broken down into 5 components and their main implications:

- Connectivity: Measures the deployment of broadband infrastructure and its quality. It is measured by 5 parameters: Fixed ADSL, Mobile ADSL, fast broadband, ultra-fast broadband, broadband price index. For example, access to fast and ultra-fast broadband services is a necessary condition for competitiveness.
- Human Capital: Measures the skills needed to take advantage of the possibilities offered by digital technology. It is measured by 2 indices: Internet users' skills, advanced skills and development.
- Citizens' use of Internet services: Represents a variety of online activities, such as the consumption of video calls of online content (videos, music, games, etc.), as well as online shopping and banking.
- Integration of digital technology by businesses: Measures the digitization of businesses and e-commerce. By adopting digital technologies, companies can improve efficiency, reduce costs and better serve customers and business partners.
- Digital public services: Measures the digitization of public services, focusing on e-government and e-health. Modernization and digitization of public services can generate efficiency gains for public administration, citizens and businesses alike (such as e-health and e-government).

2 Methodology

2.1 Population and Sample

Data for GDP per capita and GDP per capita of the previous year for each country in each time period have been obtained from Eurostat [3] and are expressed in millions of Euro at current prices. The data for the Digital Economy and Society Index (DESI) for each country in each time period has been obtained from the European Commission reports where the DESI index for each country is analyzed [2]. In our case we have chosen the countries related to the Eurozone, that is, we have data for 19 countries for which we have taken into account the time period 2015–2018.

2.2 Variables

In the following analysis, the variables selected are the following, so that we can observe, as anticipated, the impact of the DESI breakdown on GDP:

GDPPP = GDP per capita
GDPAN = GDP per capita of the previous year
desia = Connectivity
desib = Human Capital
desic = Use of internet services by citizens
desid = Business Integration of Digital Technology
desie = Digital public services

2.3 Estimation Techniques

For the model estimation we have used panel data, combining cross sections over several time periods. Specifically, we have followed the methodology of applying fixed effects, this being the most elementary and consistent methodology and the model to be estimated as in Eq. (1):

$$\log(\text{GDPPP}) = \beta_1 \log(\text{GDPAN}) + \beta_2 \log(\text{desia}) + \beta_3 \log(\text{desib}) + \beta_4 \log(\text{desic}) + \beta_5 \log(\text{desid}) + \beta_6 \log(\text{desie}) + u_{i,t} \quad (1)$$

The expression of the model has been elaborated by us and we have chosen to adopt logarithms as it allows us to understand the results more easily. In the model we take into account the GDP per capita of each country for the current and previous year considering the period 2015–2018 and all the disaggregated components of the DESI index during the same period. To estimate the model, we have used the R software, a free programming software, oriented to the statistical analysis, that through different libraries allows to design econometric models and to analyze them statistically.

3 Results

As a first step prior to the development of the study we have carried out an analysis of the correlations that can be seen in Table 1, where a relationship is shown clearly between GDP per capita of the previous year and GDP per capita of the current year. With regard to the rest of the correlations, it is understood as not high, the most significant relationship being that between the GDP per capita of the current year with regard to the desib variable, specifically at 0.62. Not observing a high correlation between the set of variables allows us to continue with the estimation of our model without the effect of multicollinearity that would be presented precisely by having a strong correlation between the explanatory variables of our model.

In code 1, we develop the model shown, where we can observe the clear and determined implication of the desic and desid variables in the GDP per capita indicator for the current year. In addition to these two implications, we can also observe the

Table 1. Correlation analysis.

	PIBPC	PIBAN	desia	desib	desic	desid	desie
PIBPC	1.000000	0.994836	0.481729	0.624592	0.299778	0.292481	−0.004682
PIBAN	0.994836	1.000000	0.482999	0.621272	0.298734	0.270716	−0.024390
desia	0.481729	0.482999	1.000000	0.577137	0.714044	0.485058	0.371132
desib	0.624592	0.621272	0.577137	1.000000	0.511841	0.432595	0.438125
desic	0.299778	0.298734	0.714044	0.511841	1.000000	0.259130	0.387760
desid	0.292481	0.270716	0.485058	0.432595	0.259130	1.000000	0.487801
desie	−0.004682	−0.024390	0.371132	0.438125	0.387760	0.487801	1.000000

Source: own elaboration

logical implication of the previous year's GDP per capita in the current year's GDP per capita, this implication being positive. It is important to point out that the implication of the DESI index variables is positive and is specifically in the use of Internet services by citizens and in the integration of digital technology by businesses.

Code 1. Regression Analysis.

```
Call:
plm(formula = log(PIBPC) ~ log(PIBAN) + log(desia) + log(desib) +
    log(desic) + log(desid) + log(desie), data = datest)

Balanced Panel: n = 19, T = 4, N = 76

Residuals:
       Min.     1st Qu.      Median     3rd Qu.        Max.
-0.06844738 -0.01367687  0.00052004  0.01000381  0.06409087

Coefficients:
              Estimate  Std. Error t-value  Pr(>|t|)
log(PIBAN)  1.3769e-01  4.8934e-02  2.8138  0.006938 **
log(desia) -2.1885e-02  6.9281e-02 -0.3159  0.753376
log(desib)  4.9375e-02  6.1260e-02  0.8060  0.423989
log(desic)  2.9505e-01  5.7769e-02  5.1073 4.918e-06 ***
log(desid)  2.7161e-01  4.3985e-02  6.1750 1.090e-07 ***
log(desie)  8.1522e-05  3.6255e-02  0.0022  0.998215
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    0.20228
Residual Sum of Squares: 0.038294
R-Squared:      0.81069
Adj. R-Squared: 0.7216
F-statistic: 36.4002 on 6 and 51 DF, p-value: < 2.22e-16
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Source: own elaboration

4 Conclusions

In developed economies, specifically in those economies with a clear technological base, different studies have been developed to really understand the implication that technological development has with indicators such as those related to the labor market.

According to the study carried out in this work, the implication between technology indicators and GDP per capita not only takes place but is also relevant specifically to aspects linked to the use of internet services by citizens and in the integration of digital technology by technology businesses. This result leads us to think clearly about the importance of technological development for a given country, since an increase in technology in different areas implies an improvement in per capita GDP. It would be interesting in future work to carry out a study of how the most developed countries have better technology and the percentages of investment in it. In addition to a comparison of how the adoption of technologies and their use in different parts of the economy affects the less developed countries of Europe compared to the major European powers, and to see if through the implementation of more technology in the less developed regions it helps a process of convergence between all European regions.

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