An analysis of the dynamics of the competitiveness for some European Countries

Un'analisi delle dinamiche della competitività a livello europeo

Andrea Marletta, Mauro Mussini and Mariangela Zenga

Abstract In 2019, the European Union registered its seventh consecutive year of economic growth, but significant differences among the European Union countries are still present. In this context, competitiveness is an important element of human-centric and sustainable economic progress. Focusing on this concept, this study proposes an approach to track the dynamics of competitive growth in a set of member countries. After selecting some economic indicators for a 6-years period from 2014 to 2019, a time trajectory showing the dynamics of innovation and digitalization for each country has been plotted. This graphical analysis allows to extract some evidences about different paths to competitiveness within the European Union.

Abstract *L'Unione Europea ha registrato nel 2019 una crescita economica per il settimo anno consecutivo, ma nonostante ciò, notevoli differenze sono ancora presenti al suo interno. Possibili motivazioni di queste differenze possono essere misurate in termini di competitività. Questo studio propone un approccio utile per tracciare le dinamiche di una crescita competitiva in un gruppo di paesi membri dell'Unione Europea. Utilizzando 6 indicatori macroeconomici dal 2014 al 2019, un'analisi delle traiettorie per ogni paese ha mostrato le dinamiche legate all'innovazione ed alla digitalizzazione. Sulla base di questa analisi grafica, è stato possibile ricavare alcune evidenze sui differenti percorsi verso la competitività all'interno dell'Unione Europea.*

Key words: Competitiveness, principal component analysis, innovation, time trajectory, digitalization

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1 Introduction

In the EU economies, several common policy actions have been made to improve economic resilience for the enterprises after the economic crisis, even if significant regional differences remain. In particular, the territorial competitiveness results an important element of regional differentiation among EU countries. According to the World Economic Forum, competitiveness at the national level is the 'set of institutions, policies and factors that determine the level of productivity of a country' [12]. In this paper, the attention is posed on a pillar of competitiveness: the innovation. Theoretical and empirical studies confirm, in fact, that innovation is a key determinant of the competitiveness of enterprises and countries [11, 6, 13]. Undoubtedly, a very significant factor influencing the realization the innovation activities is the R&D expenditure from government and business sector [1]. On the other hand, considering the sectors, ICT plays a key role in enabling innovations in many technological and economic activities.

The aim of the paper is to provide an overview of the dynamics of the competitiveness for some EU countries, limiting to two dimensions of the innovation: Research & Development and digitalization.

The paper is structured as follows: the second section presents the method to analyse three-way data, the third section describes the data and the results for 10 EU countries observed for 6 years. The section four concludes the paper.

2 Methods

In this study, a set of variables for a subgroup of EU countries is observed over the 2014-2019 period. These data form a multivariate time array $\mathbf{X}$ [8, 4], the structure of which is

$$\mathbf{X} \equiv \left\{ x_{ijt} : i = 1,\ldots,I; j = 1,\ldots,J; t = 1,\ldots,T \right\} \tag{1}$$

where i is a generic unit (i.e. a country), j is one of the observed variables and t is a year within the 2014-2019 period. Such three-way data can be re-arranged to obtain the so-called multivariate time trajectories [2, 3, 4], displaying the path of each country over the years on a J-dimensional space.

The re-arrangement of the multivariate time array $\mathbf{X}$ takes place in two steps. The observed values for all countries in a given year t are selected from the multivariate time array $\mathbf{X}$, obtaining an $I \times J$ matrix which is called "slice" [8, 4].

Once a slice has been created for each year t (with $t = 1,\ldots,T$), the slices are stacked one on the top of the other until the matrix $\widetilde{\mathbf{X}}$ with $I \cdot T$ rows and J columns is achieved. The generic row of $\widetilde{\mathbf{X}}$, denoted by $\mathbf{x}_{it}$, contains the observed values for country i in year t:

$$\mathbf{x}_{it} \equiv x_{i1t},\ldots,x_{iJt}. \tag{2}$$

When a single country i is considered, the matrix displaying the time trajectory of country i is obtained by selecting the J-dimensional vectors $\mathbf{x}_{it}$, with $t = 1, \ldots, T$, from $\widetilde{\mathbf{X}}$ [5]:

$$\widetilde{\mathbf{X}}_i \equiv \{\mathbf{x}_{it} : t = 1, \ldots, T\}. \tag{3}$$

When PCA is applied to $\widetilde{\mathbf{X}}$ and only the first two PCs are held, we obtain a two-dimensional plane [7, 9, 10] in which the time trajectory of each unit is depicted in the space spanned by the first two PCs. The advantage of such an approach is that the time trajectory of a country can be displayed by connecting its PC scores, calculated for each year in the period considered, in a Cartesian plane.

3 An analysis of dynamics in competitiveness at EU level

Data are from Eurostat database, which provides high quality statistics and data on Europe. Eurostat produces European statistics in partnership with National Statistical Institutes and other national authorities in the EU Member States.

Data refers to six indicators for ten European countries from 2014 to 2019. Final dimension of the dataset is composed by 10 countries $\times$ 6 years equal to 60 rows $\times$ 6 columns representing variables.

In particular, the considered indicators are:

- Business Expenditure in R&D (BERD);
- Government Budget Appropriations or Outlays on R&D (GBAORD);
- Enterprises that provided training for ICT skills (ICTTRA);
- Enterprises that recruited ICT specialists (ICTREC);
- Employment in high- and medium-high technology (HIGEMP);
- Employed persons with ICT education by tertiary education (ICTEDU).

The BERD indicator involves data about R&D expenditure and R&D personnel broken down by the following institutional sectors: business enterprise (BES); government (GOV); higher education (HES); private non-profit (PNP); Total of all sectors. The R&D expenditure is further broken down by source of funds; type of costs; economic activity (NACE Rev.2); size class; type of R&D; fields of research and development; socio-economic objectives and by regions (NUTS 2 level). The GBAORD indicator is concerning Government Budget Allocations for R&D. GBAORD data are measuring government support to research and development activities, and thereby provide information about the priority Governments give to different public R&D funding activities. BERD and GBAORD data are available in Euro per inhabitant. The ICTTRA variable is the percentage of the enterprises that provided training to develop/upgrade ICT skills of their personnel. Data are considered for all enterprises, without financial sector (10 persons employed or more).

The ICTREC is computed as enterprise recruited/tried to recruit personnel for jobs requiring ICT specialist skills, the unit of measure is the percentage of enterprises considering all enterprises, without financial sector (10 persons employed or

more). The HIGEMP variable is represented by employment in high- and medium-high technology manufacturing sectors expressed in percentage of total employment. The ICTEDU indicator refers to employed persons with ICT education by educational attainment level, in particular, it is expressed as the percentage of employed with tertiary education (levels 5-8) over the total.

The selected countries for this study are: France and Germany belonging to the group of Central-Western Europe countries, United Kingdom and Ireland for the Anglo-Saxon area, Portugal, Italy, Greece and Spain of the Mediterranean area and Polonia and Romania for the East Europe.

Following the procedure in the previous section, a PCA has been computed on the 6 indicators obtaining 2 factors explaining 80% of the total variance. The rotated components matrix has been presented in Table 1.

Variables	PC1	PC2
BERD	**0.886**	0.401
GBAORD	**0.879**	0.383
ICTTRA	0.571	**0.672**
ICTREC	0.238	**0.906**
HIGEMP	**0.832**	-0.354
ICTEDU	-0.033	**0.701**

Table 1: Rotated components matrix for PCA

The two components are strictly related to two sub-groups of indicators: the first component is identified by BERD, GBAORD and HIGEMP and it is named "Research & Innovation", while the second one is correlated with ICTTRA, ICTREC and ICTEDU and is named "Digitalization". Beyond the coordinates of the variables, the trajectories for two countries, Germany and Greece are represented in Figure 1.

These two countries have been chosen to underline the difference in positioning for the two trajectories in the graph. The trajectory for Germany is positioned in the first quadrant of the graph, this means that Germany is a country with a high level of Research & Innovation and Digitalization. On the other hand, Greece is placed on the left side of the plot, denoting low levels of Research & Innovation, the level of digitalization is growing until a level close to the German one.

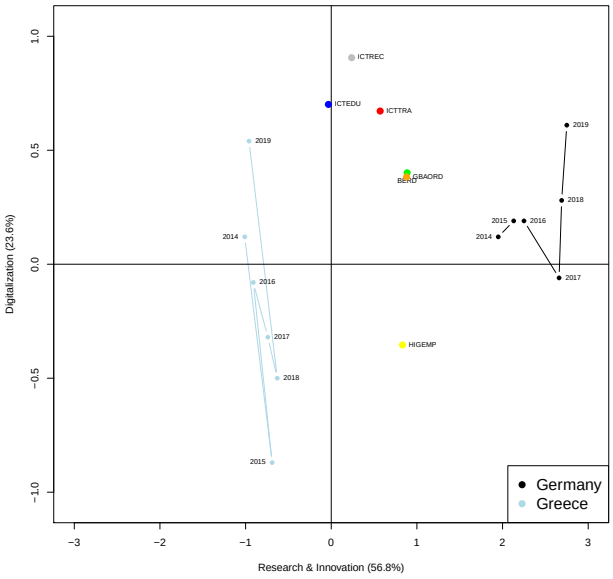

Fig. 1: Variables on cartesian plane and trajectories for Germany and Greece from 2014 to 2019

The representation of the trajectories on the cartesian plane allows to classify the countries on the basis of the quadrant occupied in the graph. For example, Germany with high level of Research & Innovation and Digitalization could be considered as a country with a high level of competitiveness. Moreover, Germany presents a quite stationary dynamic in the study because of the starting values of the considered indicators. On the other hand, Greece could be named as a country with low competitiveness because the trajectory is placed on the third quadrant for 4 years. Since the point for 2019 is positioned in the second quadrant, the competitiveness of Greece is growing thanks to indicators in digitalization. Figure 1 evidences an acceleration of innovation dynamic both for Germany and Greece in the last two years because of raising values for ICTEDU.

4 Conclusions

Reducing regional inequalities within the EU is a priority for the EU policy makers. The task of monitoring the convergence process among regional economies needs a comprehensive analysis of the dynamics in various areas related to inequality, such as per capita income, healthcare, education and job opportunities. In this scenario, disparities in competitiveness are among the main sources of inequality among the

EU member countries. Two pillars of competitiveness are innovation and the spread of digital skills, which are key drivers to create new job opportunities and to increase employability. This paper examines the convergence process in innovation and digitalization for a set of EU member countries by using time trajectories describing the paths of such countries over the 2014-2019 period.

There is evidence that the richest countries (e.g. Germany) perform better in innovation and digitalization than the poorest ones, even though some of them (e.g. Greece) show a path of improvement which may suggest the tendency to catch up with the most competitive countries. Future works could concern about the use of other dimension-reduction techniques as Dynamic Factorial Analysis to measure differences in competitiveness for European countries.

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