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SUMARIO

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The National Technology Implementation Index[1]

Índice de Implantación Tecnológica Nacional

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PALABRAS CLAVES: Inserción ICT; Índice de Implantación Tecnológica Nacional; Análisis de componentes principales; Industria 4.0.

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ABSTRACT:

We propose an index to measure ICT insertion in small and medium-sized enterprises in Spain (SMEs). Using data from 17 Spanish Autonomous Communities and 2 Autonomous Cities, and performing a Principal Components Analysis, we construct the National Technology Implementation Index (NTII) as a combination of five dimensions: (1) ICT expenditure, (2) ICT specialists, (3) Access to information, (4) Exchange of data and (5) Advanced technology, along with twenty different variables. Madrid, Catalonia and Navarra have the higher degrees of ICT implementation. With more data available, this Index will permit international comparisons.

RESUMEN:

Se propone un índice para medir la inserción de las TIC en pequeñas y medianas empresas en España. Usando datos de 17 comunidades autónomas españolas y 2 ciudades autónomas, y realizando un análisis de componentes principales, construimos

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el Índice Nacional de Implementación de Tecnología como una combinación de cinco dimensiones: (1) gasto en TIC, (2) especialistas en TIC, (3) Acceso a información, (4) Intercambio de datos y (5) Tecnología avanzada, junto con veinte variables diferentes. Madrid, Cataluña y Navarra tienen los mayores grados de implementación de las TIC. Con más datos disponibles, este Índice permitirá comparaciones internacionales.

1. INTRODUCTION[2]

Technological advancements made on the last decades, particularly those related with information and communication technologies (ICT) - such as the emergence of the computer and the explosion of the Internet - and their application to industry production have led to a new concept: Industry 4.0.

The term Industry 4.0 has been coined by the German Government to describe the digitalization of industrial systems and processes, and their interconnection through the Internet of things to arrive at a new vision of the factory of the future (Aguilar, 2017).

Current technologies make it possible to use the information at the moment it is generated, as a result of the convergence of electronics, information technology and telecommunications. The grouping of these three branches constitutes the axis of technological development that is transforming society with profound social, economic and cultural changes.

ICT is of central importance in the modern world. For example, and as stated by Oulton (2012), after the growth rate of U.S. labor productivity on the 1990s, many highly influential growth accounting studies were published (e.g. Jorgenson et al., 2007, 2005, 2004; Oliner and Sichel, 2002, 2000; Stiroh, 2002; Jorgenson and Stiroh, 2000a, 2000b). These studies all attributed a high proportion of the productivity resurgence to ICT and found that most of the improvement was due to the use of ICT equipment by other industries (capital deepening) rather than to the production of ICT equipment by the ICT industries themselves. Similar studies have been published for the U.K. (Marrano et al., 2009; Oulton and Srinivasan, 2005; Oulton, 2002), and for the G7 (Schreyer, 2000).

2 This paper is a developed versión of a chapter book published in Fernandez-Crehuet, J.M. and González, M.L. (2018) Estudio de la implantación de las TIC en las PYMES españolas: cálculo de un índice de implantación tecnológica in Huerta, E. and Moral M.J. (Ed.), Innovación y Competitividad: desafíos para la industria española (pp. 229-265). Madrid, España.

The effect of ICT and Internet has promoted a series of changes in various aspects of people's lives, which has led to the creation of new products and services, expansion of markets, changes in working styles, in spending free time, in relationships with institutions, etc. (Jiménez et al., 2009).

Advances in technologies are dramatically increasing access to information and allowing a treatment ever more rapid, complex and immediate of data, communication, information and knowledge. All of this influences a greater efficiency, proximity and productivity in the business environment. From a business perspective, one of their key success criteria depends, on a large scale, on their ability to adapt their processes to technological innovations and their skills in exploiting them for profit. Currently, business processes are framed in dynamic environments influenced by constant transformations, leading to configure a new knowledge economy.

From a historical point of view, the ICT revolution marks a decisive moment in our society, as it is changing the way of generating, producing and distributing products, as well as the forms of communication, leisure time and work; making it crucial to quickly assimilate the changes and to introduce them in a progressive but efficient way in everyday life.

Following a more social approach, Kofi Annan expressed the usefulness of ICTs in the inaugural speech of the WSIS (World Summit on the Information Society): "*Information and communication technologies are not a panacea or a magic formula, but they can improve the lives of all the inhabitants of the planet, tools are available to reach the Millennium Development Goals, instruments that will advance the cause of freedom and democracy and the necessary means to spread knowledge and facilitate mutual understanding*"(Annan, 2003).

Moreover, the Organization for Economic Cooperation and Development (OECD) establishes that ICTs are essential to boost economic growth, competitiveness and productivity. The adoption of ICT, therefore, becomes a pressing and decisive need not only for the achievement of competitive advantages but also for the very survival of companies in dynamic global markets (Jiménez et al., 2009). Spain, for instance, encourages the training of people in the technological area, the development of strategies that allow progress towards the construction of an information society and, ultimately, the improvement of ICT skills (OECD, 2012).

All of these reasons present a solid argument to acknowledge the importance of ICT insertion analysis into business and everyday life.

In this paper we offer a global view of the phenomena, ranking ICT insertion. We use data from 17 Spanish Autonomous Communities and 2 Autonomous Cities, and the Principal Components Analysis to construct the National Technology Implementation Index (NTII) as a combination of five dimensions and twenty variables: (1) ICT expenditure, (2) ICT specialists, (3) Access to information, (4) Exchange of data and (5) Advanced technology.

Results show that Castile-La Mancha, Asturias and Ceuta have the lowest ICT insertion, while, Madrid, Catalonia and Navarra are the regions that have a higher degree of ICT implementation.

The contribution of our paper to the literature is the proposal of an index that ranks the ability of businesses and communities to implement ICTs. In the process, we pool diverse factors, grouping them according to different dimensions and building a ranking based on those factors. Furthermore, our analysis recognizes the multidimensional nature of the technology phenomena. We are not aware of another literature contribution that follows the same considerations and methodology. As international data becomes available, this ranking can be extended to incorporate cross-country comparisons.

The remainder of the paper is organized as follows. Section 2 describes the background used for the inclusion of the five dimensions on NTII. Section 3 describes the data and main variables used to compute the index. Section 4 presents the methodology, and Section 5 describes the computation of the index and our main results. Section 6 concludes the paper.

2. BACKGROUND

It may seem complicated to develop a competitive advantage in a market with so much information, in which technology is available to any company. Companies must anticipate the needs of customers (Lorenzo, 2014). And it seems that the new business success will consist in knowing before the consumers what they need. To achieve this goal, it is necessary to have a large amount of information on each user, know how to manage it and weigh it properly, thus being able to draw conclusions about the products, services or experiences that interest the client to be the first to offer them, almost in real time.

In fact, many companies are already putting it into practice, using even more advanced techniques to extract and refine data, in order to predict consumer behavior. The really challenging issue is to unify the attributes of the consumer to create a true profile of the same. The problem is the need to develop a unique vision of the customers in all the channels and devices and applications they are using (Chester, 2014). This forms part of a larger-scale scenario, one of digital transformation, the transformation of business necessary to survive the digital age, whose challenge lies in management, in creating different governance, which obviously will be facilitated by technology.

One of the most successfully used models to analyze ICT insertion and implementation is the *Technology Acceptance Model* (TAM). Davis (1989) developed this model based on the theory of reasonable action (TRA) and theory of planned behavior (Marangunic and Granic, 2015; Ajzen and Fishbein, 1980). The TAM was specially designed to predict the acceptance of information systems by users in organizations. According to Davis (1989), the main purpose of TAM is to explain the factors that determine the use of TIC by a significant number of users.

This model is used to predict the use of ICT based on two main characteristics: Perceived Usefulness, and Perceived Ease of Use. Perceived utility refers to the degree to which a person believes that using a particular system will improve their performance at work, and the perceived ease of use indicates to what degree a person believes that using a particular system you will make less effort to perform your tasks. This model proposes that the perceptions of an individual regarding the perceived usefulness and ease of use of an information system are conclusive to determine his intention to use a system.

According to Yong et al. (2010), the TAM suggests that utility and ease of use are determinant in the intention that an individual has to use a system. Although the TAM helps to know if a technology is going to be used optimally, it is necessary to identify the external variables that directly influence the usefulness and ease of use perceived by the users of the ICT and determine the relationship they have with the result of the use of these technologies. Today, the optimal use of ICT in organizations is a necessity, because of the importance they have in the production of quality goods and services, together with the fact that they are becoming more accessible.

However, one of the main problems in Spain is the small number of innovative companies, the inefficiency of knowledge transfer and management instruments, the limited weight of the sectors of medium / high technology, as well as, low absorption capacities, especially in SMEs (Small and medium-sized enterprises). Moreover, the productive fabric of Spain is characterized, among other aspects, by a strong presence of traditional sectors with a low incorporation of R&D in its processes and products, in an economy essentially of services (Ardalán, 2015). This shows that Spanish SMEs have a long way, in line with what is intended to be addressed in this paper, to the insertion and adaptation of ICT to their business model.

Spanish SMEs, autonomous communities and cities have been the focus of many studies, such as economic outsourcing and commercial distribution in Andalucía (Soler, 2001; Asián, 2000), local markets in Valencia (Casado, 1996), human capital in Castellón (Molina and Martinez, 2004) and even a regional competitiveness index for Spain (Macha Navarro et al., 2017).

It is the intention of this paper to advance in Spanish studies by proposing an adequate alternative to measure and evaluate ICT insertion in small and medium-sized enterprises in Spain considering 17 Spanish Autonomous Communities and 2 Autonomous Cities.

In the next section, we will provide the data used for the National Technology Implementation Index.

3. DATA

Our data source is a survey on the use of ICT and Electronic Commerce in companies (ETICCE) on the period 2015-2016 from the National Institute of Statistics (INE, 2016). The final sample obtained is 14,557 companies with 10 or more employees around Spain. The following 19 regions have been considered: Andalusia, Aragon, Balearic Islands, Canary Islands, Cantabria, Castile and Leon, Castile-La Mancha, Catalonia, Valencia, Madrid, Navarra, Ceuta, Extremadura, Galicia, La Rioja, Melilla, Basque Country, Asturias and Murcia.

This paper is proposed as a specific tool to evaluate and analyze the degree of ICT insertion in SMEs in Spain, examining certain crucial factors that can have a positive effect, if they are put into practice. For this, it has been studied what elements may be related to the behavior of the technology. Then, we group these factors into five dimensions, according to their relevance to the following aspects: *ICT expenditure, ICT Specialists, Access to information, Data exchange and Advanced technology*.

For the measurement of ***ICT expenditure***, the costs incurred in ICT products are differenced according to these variables: Total Expenditure (thousands of euros) in *Information and Communication Technology assets*, Total Expenditure (thousands of euros) in *software, standard or customized* and Total expenditure (thousands of euros) in *services and consultation of information technologies*, *telecommunications services or other ICT services*.

This category is shown as an explanatory variable of productivity, even though investment is also affected by use. Both magnitudes are correlated. The existing heterogeneity in Europe regarding ICT use and expenditure can influence the difference in the growth and productivity rates. Portugal, Spain, Italy and Greece are the European countries with the least development in the sector (Ramos et al., 2007). It is true that this assertion was in the middle of an economic crisis and it may have changed positions, but the establishment of spending in favor of ICT as an artifact to stoke the Spanish economy is still valid.

For the measurement of ***ICT Specialists***, we considered if the company employs ICT specialists (*employability*), as a percentage of companies that claim to have such specialists; if workers are provided with training activities to develop or improve knowledge about the ICT (*training*), as the percentage of companies that provided ICT training activities to their employees. It also considers the interest or desire to increase its workforce in this area (*hiring*), such as the percentage of companies that hired or attempted to hire ICT specialists.

ICT Specialists captures the boom in skills and technological competencies required in the workplace. ICT specialists are defined as those who have the capacity to develop, operate and maintain systems used to store, process and send information and for whom ICT is the main part of their work. (OECD, 2004)

Moreover, ICT have been the cause of significant changes, among them, employment patterns, managers and researchers have a natural interest in the employment of ICT professionals. Having a group of these specialized workers is a critical factor to ensure the development, installation and service of ICT. Therefore, SMEs have two options: invest in the training of their staff, which includes the cost of resistance to change, or hire new employees with the necessary skills already acquired.

During the last decade, the employment of ICT specialists in the EU-28 has resisted the effects of the slowdown and uncertainty in the global labor markets, keeping on an upward path. This growth, in the employment of ICT specialists, was 3% during the ten-year period 2006-2015, eight times more than the average growth rate of total employment during the same period. (EUROSTAT, 2017).

For the measurement of ***Access to information***, we obtained information on workers' availability of using devices with connection to the network to perform their tasks, measured as the percentage of *employees using computers* connected to the Internet for business purposes. It also measures the percentage of personnel who are provided with a portable device that allows the *mobile Internet connection* for business use, and the percentage of companies that provide their employees with *remote access* to e-mail, documents or applications of the company. Finally, the percentage of companies with *website* is also considered.

In Spain, 99.1% of the staff of companies with 10 or more employees have a computer, a percentage that has remained unchanged in recent years since it has already reached almost the top of it. The Internet connection also presents a similar stability for the same reason, for a while this indicator has remained at 98% levels. (INE, 2016).

In 2016, 69% of the companies in the EU provided the staff with portable devices that allowed a mobile Internet connection for business use (EUROSTAT, 2016). This variable is strongly linked to remote access because the main objective of portable devices is that workers can perform their work from virtually any site and to do so, they must have the necessary applications, tools, documents and data. Remote access for communication and the transmission of internal information leads to increased productivity, reduced costs and makes all its workers active members of a corporate network.

In the case of SMEs, they usually are simple, where the content offered is presented in easily distinguishable parts so that the user can websites identify the main sections of the website and access information about the company or its products services (Dueñas et al., 2016).

For the measurement of ***Data exchange****,* we study the number of companies that enjoy the benefits of *open source software*, measured as the percentage of companies that use some type of open source software. Similarly, intercommunications with the *Public Administration* are recorded, measured as the percentage of companies that interacted with the Public Administration through the Internet. Finally, it is considered valuable, more and more, the close relationship with customers, presenting itself as a competitive and growth advantage when knowing the interests of the target public. Therefore, companies that have some computer application to manage customer information are considered, measured as the percentage of companies using Customer Relationship Management tools (*CRM tools*).

According to a recent Gartner report, the market for Open Source database management systems has grown 31% since 2013 and generates about 500 million dollars. According to its forecasts, in 2018 70% of the database management systems will be Open Source (Moré, 2016). This forecast suggests that it will have a great evolution, doubling in a year and a half, showing the growing relevance of this indicator in the technological field. There are different reasons why companies interact with the Public Administration through the Internet without needing any additional paperwork, the most widespread are: obtaining information, obtaining or returning forms or forms, electronically filing taxes and the declaration of contributions to Social Security.

Recent studies show that companies with a fully implemented CRM system can increase sales by 29% (Forbes, 2013). Moreover, it is considered that the adoption of CRM improves the marketing performance and, therefore, the sales when renewing the service and the relations with the clients. Advances come, for example, from providing easy-to-use mechanisms for receiving complaints, identifying potential problems before they occur, in general, by facilitating communication with the client and anticipating customer preferences (Giannakouris and Smihily, 2013).

The measurement of the dimension ***Advanced Technology*** includes the collection platforms, tools and "novel" ways that help in the development and business growth in different ways.

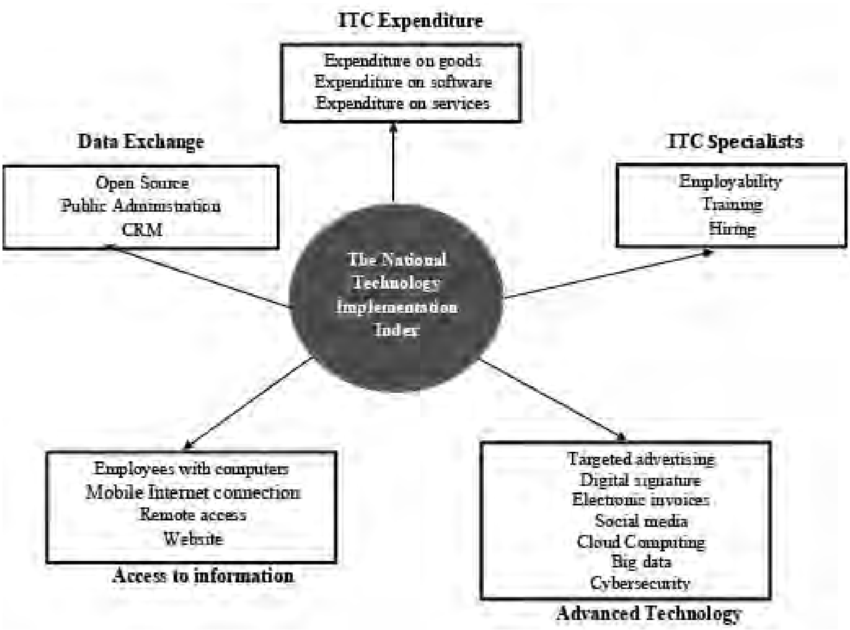
For example, *Targeted advertising* is the most widespread and used among companies that opt for paid advertising to be known, is measured as the percentage of companies that pay to advertise on the Internet using targeted advertising methods and it is based on web page content or search of keywords by users, based on the tracking of previous activities of users or profiles on the Internet, based on geolocation of Internet users and directed advertising with a method different from the previous ones.

Other variables include: the *digital signature* that helps streamline procedures in SMEs and is represented as the percentage of companies that use a digital signature in some communication sent from their company. The use of *electronic invoices* reduces the risk of losses and involves savings in cost of copies and storage of paper, and it is evaluated as the percentage of companies that sent electronic invoices (eg EDI, UBL, XML.) to other companies or public administrations.

Furthermore*, Social Media* includes applications based on Internet technologies or communication platforms to connect, create or exchange online content with customers, suppliers, partners ... or within the company itself in the exercise of the activity itself. Included in this variable are social networks (e.g. Facebook, LinkedIn, Tuenti, Google+, Viadeo, Yammer) blogs of companies or microblogs (e.g. Twitter, Present-ly, Blogger, Typepad), websites that share content multimedia (e.g. Youtube, Flickr, Picassa, SlideShare, Instagram) and knowledge sharing tools, based on Wiki. This variable is measured as the percentage of companies that use Social Media.

In addition, we study if the company shares electronic and automatically between the different areas, using a single software tool or several that share the information extracted from a common database. This is known as *Cloud Computing* and includes: the purchase of E-mail services, Software Office,

FIGURE 1
CLUSTERS OF THE NATIONAL TECHNOLOGY IMPLEMENTATION



Fuente: Elaboración propia.

database server, storage of files and the purchase of financial or accounting software applications, among others. It is measured as the percentage of companies that buy a Cloud Computing service used over the Internet.

Big Data is, in the ICT sector, a reference to systems that manipulate large datasets from M2M communications, measured as the percentage of companies that analyzed Big Data and includes data from their own company with sensors or smart devices, data by geolocation from portable devices, data generated by social media and data from other Big Data sources.

The objective of testing *cybersecurity* is to know if companies have defined measures, controls and procedures applied to ICT systems to ensure the integrity, authenticity and availability of their systems. It is measured as the percentage of companies that use internal security systems, these internal systems can be: secure password authentication, user identification and authentication using hardware elements, user identification and authentication using biometric elements, the backup of external data and protocols for the analysis of security incidents.

4. METHODOLOGY

For the construction of the National Technology Implementation Index, Principal Component Analysis (hereinafter referred to as PCA) will be used. PCA is a statistical technique that allows the extraction of important information from a table of multivariate data to express this information as a set of few new variables called main components. These new variables correspond to a linear combination of the originals and are constructed according to the order of importance in terms of the total variability that they collect from the sample. It is a widely used method in the literature (e.g. Fernandez-Crehuet et al., 2017, 2016; Jemmali and Sullivan, 2014; Bellido et al., 2011; Krishnakumar and Nagar, 2008; Lai, 2003, 2000; Filmer and Pritchett, 2001)

The objectives of this method are:

a) Reduce the dimensionality of multivariate data to fewer main components than the number of original variables.
b) Eliminate redundant information by reducing the impact of information redundancy as it does not take into account the accumulation of covariance among primitive variables.

c) To capture in the new components part of the total variance, with a minimum loss of information, assuring the incorrelation and the maximum discriminating power between them.

We use the methodology described in the OECD handbook (OECD, 2008), which includes the application of PCA analysis, for the construction of the Technology Achievement Index (TAI), applied to 28 countries. PCA groups together individual indicators that are collinear to form a composite indicator that captures as much as possible of the information common to individual indicators. The idea of PCA is to account for the greatest possible variation in the indicator set, using the smallest possible number of factors, and weighting intervenes only to correct for overlapping information between two or more correlated indicators (and is not a measure of the theoretical importance of the associated indicator).

One of the requirements for a correct application of PCA is that variables must be measured on the same scale. While there is, on occasion, no need to normalize the variables, as they are already measured on the same scale (Nardo et al., 2004), in other cases, variables must be normalized.

Data section shows that all of them are measured in percentages, except for the 3 ITC expenditure variables, measured in thousands of euros. For this reason, it is necessary to find a way to homogenize them. There are several methods for standardizing data, such as the range of observations, standardization, distance to or from a reference, or by means of indicators above or below average (OECD, 2008). Each method has its advantages and disadvantages such as loss of information at the interval level, sensitivity to outliers, arbitrary choice of categorical scores and sensitivity to weighting.

The normalization method select is standardization, which is the use of z-scores of the variables. In doing so, we calculate the average (μ) and standard deviation (σ) of the variables we obtain the "z-scores" value, according to the following expression:

where "x" represents the value of the variable for the different autonomous region. (The results of standardization are shown in the appendix).

Following Spector (1992), the number 3 is established as a minimum of variables per dimension, taking into account that three elements per category should be seen as an absolute minimum, and certainly not as an optimal. All established groups have at least 3 elements, so this restriction is met.

To assign weights to the variables, which will determine the importance of the variable in the corresponding dimension, first select the number of main components for each dimension. There are several criteria that can be used to select the number of components, according to OECD (2008), are applied together:

1. Those that have their own values (or self-values) associated greater than one.
2. Those that individually provide an explained variance of more than 10%.
3. Those presenting an accumulated explained variance greater than 60% of the total explained variance.

Since SPSS only allows you to select the limit of the self-value and not the individual or cumulative variance, this condition will be imposed.

Secondly, the factor loads given by the PCA (through the matrix of components rotated or not rotated as the case may be, this is explained below) are used to assign the variables to the components, where each variable is assigned to the component where the factor load is the highest in absolute value. For example, if we consider the open source software variable (Open Source), the factor loads for this variable are -0.005 and 0.947 in the first and second component, respectively. Since the highest factor load corresponds to the second component, we assign this variable to the second component of the Data exchange dimension.

Thirdly, following the OECD (2008) in its calculation of the TAI index, a matrix is constructed with the squared factor load value. Then, all factors are added to the square of each component and the squared factor loads are divided by the same sum. This results in the proportion of the total unit variance of the indicator. For example, following the same variable, Open Source, the original load factor of the variable is 0.947 and its square is 0.897. This square factor is corrected by dividing by the sum of all factor loads squared of the variables in component 2 (1,136), which leads to the value of 0.789.

Finally, we construct the final weight of the variables to be included in each dimension, using scaled squared factor loads to add the unit and using the proportion of total variation that each component can explain. For example, if considering the Data Exchange dimension, components 1 and 2 of this dimension are able to explain 45.82 and 37.8 % of the total variation, and thus explain about 84 % of the total variation. Outside of this total variation explained, components 1 and 2 represent 54.8% (45.82 x100/83.6) and 45.2 (37.8 x100/83.6) of the variation explained.

We use these percentages of the relative variation explained to correct the squared factor loads of the variables, thus obtaining the final weights.

5. THE NATIONAL TECHNOLOGY IMPLEMENTATION INDEX

The construction of a complex index avoids costly exploration of correlations and improves consultation performance. In this case, a composite index has been constructed to assess the level of ICT insertion in Spanish SMEs, distinguishing by regions.

Firstly, the results of applying PCA to the variables included in the ICT expenditure dimension will then be shown. The variance explained by the initial solution and the extracted components is shown.

The column called Total gives the eigenvalue, where the emphasis is appreciated in the importance of the proper values to define the unique nature of a certain linear transformation. The % of Variance column gives the ratio, expressed as a percentage, of the variance contributed by each component to the total variance of all variables. The column % Cumulative gives the percentage of variance captured by the first n components.

TABLE 1

EIGENVALUES FOR THE VARIABLES INCLUDED IN THE' ICT EXPENDITURE' DIMENSION.

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.876	95.857	95.857	2.876	95.857	95.857
2	0.083	2.778	98.635			
3	0.041	1.365	100			

Fuente: Elaboración propia.

For the initial solution, there are as many components as there are variables, and in a correlation analysis, the sum of the eigenvalues (or self-values) is equal to the number of components (in this case 3). As it has been established that only the self-values greater than 1 were extracted, only one main component forms the solution extracted in the Expense dimension. This is why the unrotating component matrix will be used.

Secondly, it is now necessary to explain the rotation matrix. This depends on the results achieved, if only one main component is obtained, SPSS does not give rotation matrix, since it is not necessary either, to see which variable goes to which component since there is only one. On the other hand, when there is more than one main factor, the rotation matrix exists. Its objective is to help in the interpretation by making the self-values more homogeneous and that the loads of each variable to each factor are more disparate, facilitating the assignment of each variable to the corresponding component.

TABLE 2
ROTATION MATRIX AND LOADS OF THE "ICT EXPENDITURE" DIMENSION FACTORS

Component Matrix non- ROTATED	Component 1	Squared factor loading	Squared factor loading (scale to sum unity)
Expenditure on goods	0.982	0.964324	0.33537073
Expenditure on software	0.972	0.944784	0.32857515
Expenditure on servicies	0.983	0.966289	0.33605412
Variation explained	95857		
Variation explained/total	1		

Fuente: Elaboración propia.

In cases that have only one major factor, the variation explained by that component on the total is equal to 1. Therefore, the weight of the variable will be determined by the factor squared unit (the last column of Table 2).

The same is true for the ICT Specialists dimension and it can be seen that the second section of Table 3 shows the components extracted. In this dimension it is again only a main component, which explains about 76% of the variability of the 3 original variables. The weights of ICT Specialist are shown in Table 4.

TABLE 3
EIGENVALUES FOR THE VARIABLES INCLUDED IN THE "ICT SPECIALISTS" DIMENSION

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.26986	75.66213	75.66213	2.26986	75.66213	75.66213
2	0.53431	17.81060	93.4727			
3	0.19581	6.527257	100			

Fuente: Elaboración propia.

TABLE 4
ROTATION MATRIX AND LOADS OF THE "ICT SPECIALISTS" DIMENSION FACTORS

Component Matrix non- ROTATED	Component 1	Squared factor loading	Squared factor loading (scale to sum unity)
Employability	0.917	0.8409	0.370456
Training	0.781	0.6100	0.268720
Hiring	0.905	0.8190	0.360824
Variation explained	75.6621344		
Variation explained/total	1		

Fuente: Elaboración propia.

For the dimension "Access to information" there is only one component with the self-value greater than 1, this component represents 61.5% of the explained variability (Table 5), assuming a loss of 38.5% of the total variability of the 4 original variables.

TABLE 5
EIGENVALUES FOR THE VARIABLES INCLUDED IN THE' ACCESS TO INFORMATION' DIMENSION

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.460541	61.51352	61.51352	2.460541	61.51352	61.51352
2	0.852626	21.31566	82.82918			
3	0.496195	12.40486	95.23405			
4	0.190638	4.765954	100			

Fuente: Elaboración propia.

TABLE 6
ROTATION MATRIX AND LOADS OF THE "ACCESS TO INFORMATION"DIMENSION FACTORS.

Component Matrix non- ROTATED	Component 1	Squared factor loading	Squared factor loading (scale to sum unity)
Employees with computers	0.902	0.813604	0.33075
Portable Conexion	0.887	0.786769	0.31984
Remote Access	0.646	0.417316	0.16965
Website	0.665	0.442225	0.17977
Variation explained	61.5135216		
Variation explained/total	1		

Fuente: Elaboración propia.

The following results have been achieved in this group. The weight of the Personal with computers variable is 0.33 and for Portable Connection, Remote Access and Web Page the weights are 0.32, 0.17 and 0.18 respectively.

In the case of Data Exchange, there are two main components. In this case, the matrix of rotated components appears. Table 7 shows the self-values, the explained and accumulated variances, both before and after extraction and rotation.

TABLE 7
EIGENVALUES FOR THE VARIABLES INCLUDED IN THE "DATA EXCHANGE" DIMENSION

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	Variance %	Cumul %	Total	Variance %	Cumul %	Total	Variance %	Cumul %
1	1.375	45.817	45.817	1.37451	45.817	45.817	1.3718	45.728	45.728
2	1.134	37.7973	83.6144	1.13392	37.7973	83.614	1.1365	37.8857	83.614
3	0.492	16.3855	100						

Fuente: Elaboración propia.

There is hardly any change from extraction to rotation, this is because the self-values have a very similar figure, so the homogenization that entails rotation is almost negligible in this case. It is worth noting that the cumulative percentage of the variation explained by the components extracted after rotation is always maintained (83.614%).

TABLE 8
ROTATION MATRIX AND LOADS OF THE "DATA EXCHANGE" DIMENSION FACTORS

Rotated Component Matrixa			Squared factor loading		Squared factor loading (scale to sum unity)	
	Comp 1	Comp 2	Comp 1	Comp 2	Comp 1	Comp 2
Open Source	-0.005	0.947	0.000025	0.896809	1.822 E-05	0.78899
CRM	0.841	-0.322	0.707281	0.103684	0.515687	0.09121
Public Admin	0.815	0.369	0.664225	0.136161	0.484294	0.11979
Variation explained	45.8171	37.79734				
Variation explained/total	0.547956	0.452043				

Fuente: Elaboración propia.

When there is more than one main factor, each variable is assigned to a component, taking into account the values of the rotated component matrix (Table 8). Thus, the Open source variable belongs to component 2 and the first component is highly correlated with the interaction with public administration and CRM tools.

Now, to calculate the weight of these variables, the value of the variability explained above is multiplied over the total of the component to which this variable belongs by the value of the unit squared factor. For example, for the CRM variable, as it belongs to the first component, it is calculated with the value 0.5479 x 0.5157, thus obtaining a weight of 0.2826.

Finally, proceed in the same way as in the previous case for the Advanced Technology dimension. However, in this result more disparate numbers of auto-values have been obtained, consequently, the variation is now diluted more homogeneously on the components (going to be 40.8% and 25.4%). This suggests that the rotated component matrix will be easier to interpret than the non-rotated matrix.

TABLE 9

EIGENVALUES FOR THE VARIABLES INCLUDED IN THE "ADVANCED TECHNOLOGY" DIMENSION

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	Varian %	Cumulat %	Total	Varian %	Cumulative %	Total	Varian %	Cumulat %
1	3.058	43.688	43.688	3.058	43.688	43.688	2.855	40.782	40.782
2	1.571	22.449	66.138	1.571	22.449	66.138	1.775	25.356	66.139
3	0.976	13.937	80.075						
4	0.599	8.5714	88.647						
5	0.402	5.7432	94.390						
6	0.308	4.4046	98.795						
7	0.0843	1.2047	100						

Fuente: Elaboración propia.

It can be seen that the two main factors account for 66% of the variability provided by the original 7 variables.

The major factors, in absolute value, were then chosen to determine which component each variable corresponds to.

The first component is highly correlated with Social Media and Cloud Computing and in contrast, e-invoices, targeted advertising and Cybersecurity have, in this order, increasingly less representativeness due to the increase in correlations with other components. As for the second component, it is highly correlated with Big Data and Digital Signature, although the latter has better representative power.

Finally, the corresponding weights have been obtained for the 20 variables of the IITPE, which allows a ranking to be carried out, by Autonomous Communities, in order to evaluate the degree of ICT implementation. The weights obtained are presented in Table 11. In this index all the variables have been considered positive because they favour the research topic. Otherwise, the weighting would be the same, but negative.

TABLE 10

ROTATION MATRIX AND LOADS OF THE "ADVANCED TECHNOLOGY" DIMENSIONAL FACTORS

Rotated Component Matrixa			**Squared factor loading**		**Squared factor loading (scale to sum unity)**	
	Comp 1	Comp 2	Comp 1	Comp 2	Comp 1	Component 2
Tarjeted advertising	0.64297	0.2052	0.41342	0.04212	0.14481	0.02373
Dig, Signature	0.09798	-0.90016	0.00960	0.81029	0.00336	0.45652
Electronic invoices	-0.65538	-0.13059	0.42953	0.01705	0.15046	0.00960
Social media	0.81543	-0.05888	0.66492	0.00346	0.23291	0.00195
Cloud Computing	0.81228	-0.14517	0.65980	0.02107	0.23112	0.01187
Big data	0.24525	0.83024	0.06014	0.68931	0.02106	0.38836
Ciberseguridad	0.78570	0.43771	0.61733	0.19159	0.2162	0.10794
Variat. explained	43.6886	22.4498				
Variation explained/total	0.66056	0.33943				

Fuente: Elaboración propia.

With the weights obtained by the application of the PCA, as explained in the previous episode, and all the normalized variables (Appendix), the autonomic ranking is constructed. It was detailed that an independent PCA was applied per dimension, and since there are 5, each of them is weighed equitably with 20%.

TABLE 11
VARIABLE WEIGHTS

Weights applied to each variable	
ITC Expenditure	
Expenditure on goods	0.335
Expenditure on software	0.329
Expenditure on services	0.336
ITC Specialists	
Employability	0.370
Training	0.269
Hiring	0.361
Access to information	
Employees with computers	0.331
Mobile Internet connection	0.320
Remote access	0.170
Website	0.180
Data Exchange	
Open Source	0.357
CRM	0.283
Public Administration	0.265
Advanced Technology	
Tarjeted advertising	0.096
Digital signature	0.155
Electronic invoices	0.099
Social media	0.154
Cloud Computing	0.153
Big data	0.132
Cybersecurity	0.143

Fuente: Elaboración propia.

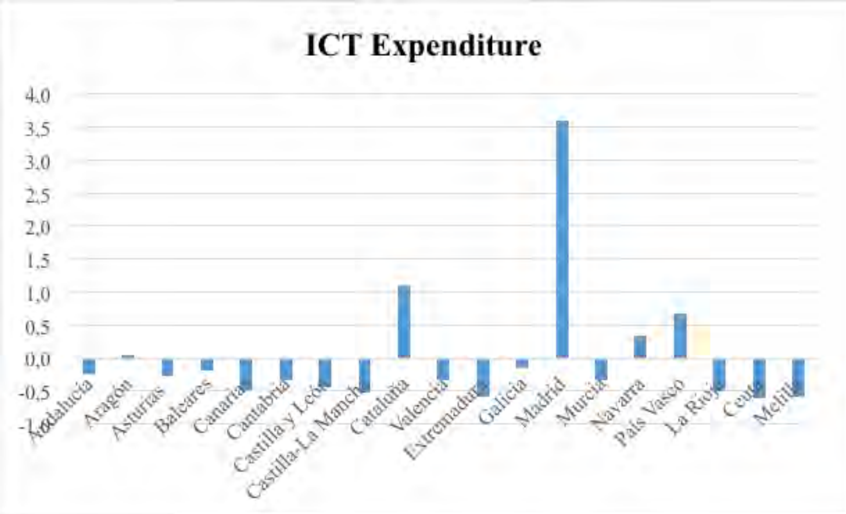
TABLE 12
RANKING OF THE NATIONAL TECHNOLOGY IMPLEMENTATION INDEX IN SPANISH SMES

	Index	Ranking	ICT Expenditure	ICT Specialists	Access to information	Data Exchange	Advanced Technology
Madrid	1.800	1	3.5895	1.9053	1.9195	0.5801	1.0057
Catalonia	1.114	2	1.0840	1.7315	1.4225	0.3953	0.9344
Navarra	0.409	3	0.3252	0.8997	0.4768	0.3290	0.0139
Basque Country	0.307	4	0.6686	0.6813	1.0721	-0.6393	-0.2464
La Rioja	0.093	5	-0.5102	0.3704	-0.1767	0.6216	0.1615
Andalusia	0.076	6	-0.2640	-0.0905	0.4937	0.1815	0.0570
Aragon	0.046	7	0.0429	-0.0443	0.4350	-0.0896	-0.1143
Valencia	-0.027	8	-0.3476	0.1218	-0.2856	0.2057	0.1706
Balearic Islands	-0.119	9	-0.1889	0.0730	-0.6416	-0.2477	0.4089
Extremadura	-0.150	10	-0.5873	-0.1579	0.0946	0.1716	-0.2715
Murcia	-0.166	11	-0.3478	0.0358	-0.5439	0.2941	-0.2691
Canary Islands	-0.249	12	-0.4914	-0.1961	-0.8637	-0.1231	0.4275
Galicia	-0.249	13	-0.1484	-0.2691	-0.2132	-0.2137	-0.4025
Cantabria	-0.350	14	-0.3516	-0.4135	-0.5347	0.0502	-0.4985
Castile and Leon	-0.371	15	-0.4521	-0.5309	-0.4056	-0.3770	-0.0894
Melilla	-0.390	16	-0.5942	-1.1278	-0.7705	0.7430	-0.2027
Asturias	-0.447	17	-0.2734	-0.6440	-0.0628	-0.9712	-0.2850
Castile-La Mancha	-0.661	18	-0.5305	-1.1629	-0.6226	-0.7500	-0.2391
Ceuta	-1.026	19	-0.6228	-1.4712	-1.0530	-1.1471	-0.8352

Fuente: Elaboración propia.

As all categories oscillate, more or less, between the same values, with the exception of expenditure in the Community of Madrid, the results obtained are not well appreciated and it is difficult to compare them. Therefore, for a better visualization, some graphics will be shown distinguishing by dimensions.

FIGURE 2
COMPARISON OF THE "ICT EXPENDITURE" DIMENSION



Fuente: Elaboración propia.

It is clear in Figure 2 that Madrid has the largest spending in ICT, followed by Catalonia (which does not reach a fifth of the expenditure made by SMEs in Madrid. Finally, the Basque Country, Aragon and Navarre are still above average.

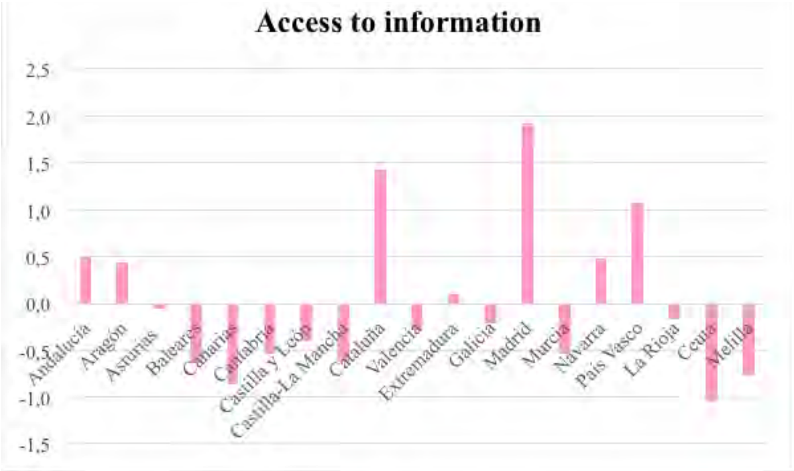
FIGURE 3
COMPARISON OF THE DIMENSION "ICT SPECIALISTS"

Fuente: Elaboración propia.

In Figure 3, Madrid and Catalonia continue to hold the top positions, but unlike the previous one, there are several autonomous regions that are well below the average, highlighting Ceuta, Melilla and Castile-La Mancha.

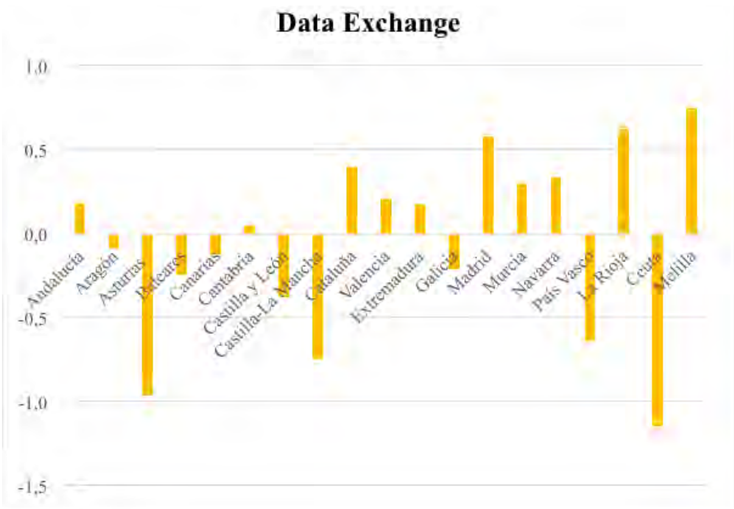
In Access to information dimension, Figure 4, the good positioning of Andalusia (4th position) stands out, which is explained by the fact that it has values that are relatively above average in the variables Personal with computers and Portable connection, which together account for 65% of the weight. However, in Remote Access and Website, Andalusia presents values below the average value, but due to its lower weighting, the overall result is very favorable. On the other hand, it is not surprising that Madrid, Catalonia, the Basque Country and Navarre have good results since they are the best AAs according to the ranking constructed.

FIGURE 4
COMPARISON OF THE DIMENSION "ACCESS TO INFORMATION"



Fuente: Elaboración propia.

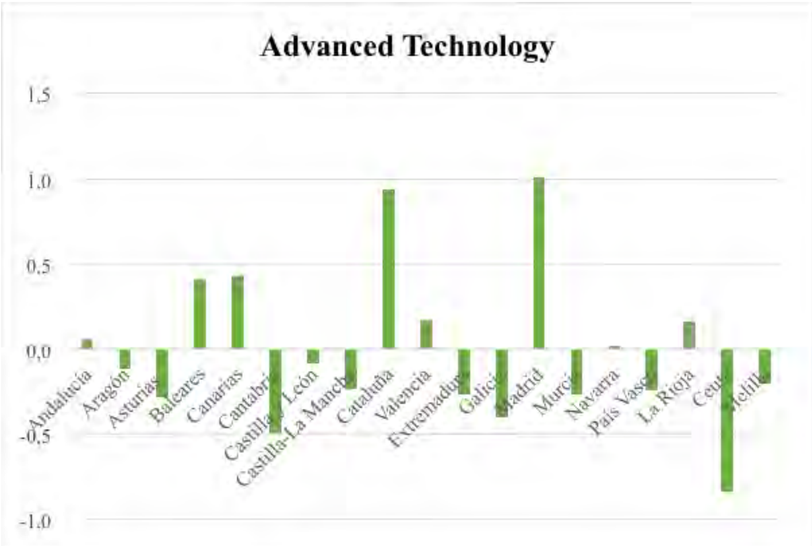
FIGURE 5
COMPARISON OF THE DIMENSION "DATA EXCHANGE"



Fuente: Elaboración propia.

In this dimension, the range of values decreases considerably (Figure 5). In addition, half of the variables are shown above and the rest below, which shows that the ACs in this group of variables are more similar. It is necessary to highlight that the autonomies with the worst figures in Data Exchange matches with those of the complete index, being Castile - La Mancha, Asturias and Ceuta.

FIGURE 6
COMPARISON OF THE "ADVANCED TECHNOLOGY" DIMENSION



Fuente: Elaboración propia.

Finally, in terms of advanced technology, the variables Digital Signature, Social Media and Cloud Computing are the most influential, with a variability of 7.288, 5.513, 5.251 respectively. This shows that there is a dispersion to be taken into account, but this lack of homogenization is compensated between the different variables that make up the dimension. Therefore, the values between regions are quite close. In the top positions, Madrid and Catalonia are once again located, as in the rest of the categories studied.

6. CONCLUSIONS

The proposed index in this paper is founded on the idea that numerous dimensions must be considered to accomplish a comprehensive assessment of the complex results and effects produced by implementing new technologies. These effects cannot be limited just to a company level because even though an innovation can provide great advantage to the innovative firm, it can also present disadvantages to the economic system as a whole, involving aspects such as unemployment, environmental balance, and technology insertion and implementation.

The task is ambitious, and the proposed indicators are only an attempt to give a systematic solution to the matter, but others can be proposed and implemented.

Several parameters have been chosen based in the idea that the implementation and insertion of new ICT is closely related to its capacity to provide both companies and society as a whole with economic results. These various parameters have been chosen to capture the 5 dimensions that seem to contribute to a quantifiable assessment of the implementation and insertion of technology.

Results from this investigation shows that, based on the data extracted from ETICCE 2015-2016, ICTs valued in the index have a level of implementation between regular and good except for *targeted advertising*, *Cloud Computing* and *Big Data* that still resist being part of a large part of SMEs (with average percentages less than 20%). The ICT Specialists category has been shown to be advanced, but certainly the data shows that there is still a lack of progress in this area. In contrast, the *Open Source* and *Cybersecurity* variables have an average value of over 86%, although it should be noted that this percentage does not measure the level of use and effectiveness of these variables, but simply the percentage of companies that claim to have some open source software and some security system.

Given the speed of technological transformation in a society is growing, it is possible to conduct more measurements every year. The proposed method permits evaluating many aspects related to new technologies and their relation to socio-economic elements. Furthermore, this allows measurement of results and effects.

Further research should focus on the consideration of different parameters, factors and elements not considered in this research, and on the comparison with other technological indices such as TAM, but applied on the same sample.

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