Multivariate dynamics of Spanish universities in international rankings

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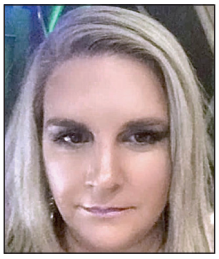

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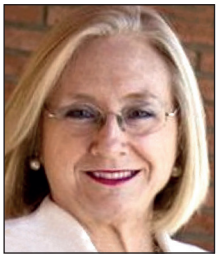

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Abstract

Global rankings help boost the international reputation of universities, which thus attempt to achieve good positions on them. These rankings attract great interest each year and are followed attentively by stakeholders in higher education. This paper investigates the trajectory of Spanish universities in the *ARWU* and *THE* rankings over the last 5 years using the dynamic biplot technique to study the relationship between a multivariate dataset obtained at more than one time point. The results demonstrate that Spanish universities achieve low positions on international rankings when analyzed using this multivariate and dynamic approach. Indeed, only a small percentage occupy good positions in both studied rankings and stand out in terms of some of the indicators, whereas most achieve weak scores in the global context. Spanish universities should attempt to improve this situation, since the prestige resulting from a good position on these lists will always be beneficial in terms of the visibility of both the universities themselves and the whole Spanish university system.

Keywords

Higher education; Internationalization; World class; Universities; *Shanghai Ranking*; *ARWU*; *THE*; Dynamic biplot; Biplot; Spanish universities.

1. Introduction

The international landscape of higher education has experienced a great boost in recent years due to the globalization and commodification of knowledge (**Knight**, 2004). The educational market has become universal, borders have disappeared, and barriers have become blurred. To compete in this new scenario, universities need to improve their global positioning by designing strategies to increase their visibility and project their offering, capabilities, and appeal (**Vázquez-García**, 2015).

Internationalization can be defined as the inclusion of the international dimension into a university's strategy regarding its teaching, research, and transfer missions, as well as the projection of its offering and capabilities (**Knight**, 2004**).** This is, therefore, a concept with multiple manifestations, including the expansion of an organization's visibility, recognition, and scope of action. One element to help promote this type of internationalization is university rankings, acting as a stage on which the competition to achieve global status is played out (**Rodríguez-Espinar**, 2018). These classifications are now impossible to ignore and are presented as arbiters of universal academic excellence (**Vázquez-García**, 2015). Their substantial impact on the internationalization of universities has been the subject of numerous investigations (**Marginson**, 2012; **Ordorika**, **Rodríguez-Gómez**, 2010; **De-Wit**, 2017; **Knight**, 2014; **Collins**; **Park**, 2016). Although the main classifications available worldwide include few indicators that measure the degree of internationalization, achieving a good position in them has a great influence on world prestige, which in turn is independent of the degree of internationalization exhibited by the functions of that organization (**Casani**; **Rodríguez-Pomeda**, 2017).

The first two rankings to be established were the *Academic Ranking of World Universities* (*ARWU*) and the *Times Higher Education World University Rankings* (*THE*), and these are still considered to be two of the best known and most influential today (**Safón**, 2012; **Marginson**, 2007; **Locke** *et al.*, 2008; **Ordorika**; **Rodríguez-Gómez**, 2010; **Rauhvargers**, 2011). They were later joined by others such as the *QS World University Rankings*, which split off from the *THE* ranking in 2010, and the *SCImago Institutions Ranking* and *Leiden World Ranking*, which focus exclusively on research results.

Academic Ranking of World Universities (*ARWU*)

The *ARWU* was published for the first time in 2003 under the name *Shanghai Jiao Tong Academic Ranking of World Universities*, being produced by the *Jiao Tong University* (China) *Center for World-Class Universities* (*CWCU*), which is why it is popularly known as the *Shanghai Ranking*. It ranks universities based on four criteria:

- teaching quality (10%)
- academic staff quality (40%)
- research output (40%)
- organization size (10%)

Teaching quality is measured by the number of alumni who have received a *Nobel Prize* or *Fields Medal* (10%). Furthermore, to measure the quality of the teaching staff, the total number of staff who have won *Nobel Prizes* in physics, chemistry, medicine, and economics or *Fields Medals* in mathematics (20%) is considered. Similarly, to measure the quality of the teaching staff, the number of highly cited researchers according to the list published by *Clarivate Analytics* (20%) is measured. Because of this indicator, such researchers have become an important asset to their universities and a frenzied race for their recruitment has ensued (**Docampo**; **Torres-Salinas**, 2013).

Research output is determined based on the number of *Nature* and *Science* articles published (20%) and the number of articles indexed in the *Science Citation Index Expanded* (*SCIE*) and *Social Sciences Citation Index* (*SSCI*) over the previous five years (20%). The final criterion in the ranking is the size of the organization (10%).

The *ARWU* is the only international ranking that obtains its data independently of the analyzed institutions (**Montané-López**; **Beltrán-Llavador**; **Teodoro**, 2017). The main criticisms leveled at this ranking focus on its research-oriented indicators (**Ordorika**, 2015; **Tomàs-Folch** *et al.*, 2015) and the inclusion of the *Nobel Prize* winner category, as these exclude a large number of universities from classification (**Yong-Amaya**; **Zambrano-Zambrano**; **Ruso-Armada**, 2018). Despite this criticism and some reluctance, it has become the basic reference worldwide (**Docampo** *et al.*, 2012) and is considered to be the most outstanding academic classification on the global stage (**Docampo**; **Cram**, 2015).

THE World University Ranking

The next international ranking to emerge in the field of higher education was the *THE* ranking, created by the company *Times Higher Education* in 2010. The *THE* ranking is based on 13 indicators, grouped into five dimensions:

- teaching (30%)
- research (30%)
- citations (30%)
- international perspective (7.5%)
- income from industry (2.5%).

The teaching dimension is determined through five variables, although the survey on the reputation of teachers and researchers accounts for half the weighting in this dimension (15%). It also measures:

- teacher-to-student ratio (4.5%)
- proportion of doctoral students and graduates (2.25%)
- percentage of doctoral students and professors (6%)
- institutional income (2.25%).

The research dimension is determined by three variables:

- researcher reputation, collected via surveys with academics (18%)
- research income per academic (6%)
- scientific output, quantified by the number of publications indexed in *Scopus* per academic (6%).

The research impact is also determined based on the citations received in publications indexed in *Scopus* (30%).

The two concepts with least weight in this ranking are international perspective and knowledge transfer. The former is measured by:

- percentage of international students (2.5%)
- percentage of international staff (2.5%)
- co-authorship of international works published in the last five years (2.5%).

The latter captures the research income obtained from industry (2.5%).

One of the major criticisms leveled at this ranking is motivated by the fact that it is largely based on reputation surveys and confidential data provided by universities (**Sanz-Casado**, 2015). Further criticism stems from the incomplete and confusing research income component since it is not standardized across countries (**Marginson**, 2014).

Although considered to be the most influential, neither of these international rankings include indicators with a high weighting for internationalization. Indeed, the *ARWU* ranking does not include any variables that directly measure this concept (**Delgado-Márquez**; **Hurtado-Torres**; **Bondar**, 2011), while the *THE* ranking does include such an internationalization indicator but gives it a low weighting in the overall ranking (7.5%). Despite this, both classifications are considered key for measuring projection at the global level and have a strong impact on national and institutional policies and strategies for the internationalization of higher education organizations (**Collins**; **Park**, 2016; **De-Wit**, 2017).

This link between rankings and internationalization strategies has resulted in differentiation within national systems through the separation of an elite sector made up of world-class universities and another consisting of more locally oriented, national establishments (**De-Wit**; **Altbach**, 2020). World-class universities are characterized by high-ranking research, a culture of excellence, and a brand that transcends national borders (**Douglass**, 2014). They are positioned in the upper echelons of international rankings and are recognized not only by other universities but also outside the education sector. Their reputation for research and teaching makes it easy for them to operate in a global market and to internationalize many of their functions (**Douglass**, 2016).

Global rankings are closely followed each year by different stakeholders in higher education. Achieving a high ranking sparks great interest, even in Spanish universities. The promotion of internationalization through rankings can lead to increased visibility and thereby enhance the image of the whole Spanish university system (**Pérez-Esparrells**, 2017). The purpose of the current study is to examine the positioning of Spanish institutions in two global rankings, as well as their trajectory over the last 5 years. The aim is to identify the institutions that have managed to be classified in the global rankings and those that can aspire to compete in the world-class group, as well as to analyze their trajectory and distinctive characteristics.

2. Methodology

International rankings have been the subject of numerous investigations focusing on the identification of the correlations and contributions of different indicators. Techniques such as factor analysis (**Luque-Martínez**; **Faraoni**; **Doña-Toledo**, 2018), principal components (**Docampo**; **Cram**, 2015), regression analysis (**Safón**, 2019), and correlation analysis (**Shehatta**; **Mahmood**, 2016) have been applied to study such classifications exhaustively. However, it is noted that the research literature lacks studies focused on the use of dynamic multivariate methods to observe the international projection of universities over time.

To carry out this research, the two oldest and most well-known global rankings were selected, viz. the *ARWU* and *THE* ranking. The *ARWU* is based on objective data, while the *THE* ranking uses reputation surveys. This also means that these two classification systems can provide a complementary snapshot of university internationalization. The following websites for the rankings were used as sources for the database design:

- *Academic Ranking of World Universities* (*ARWU*)
  http://www.shanghairanking.com
- *Times Higher Education World University Rankings* (*THE*)
  http://www.timeshighereducation.com/world-university-rankings

The values of the variables for Spanish universities were collected for the years 2016 to 2020.

Dynamic biplots were selected as the technique to evaluate the relationship between the multivariate dataset analyzed at more than one time point. This technique was proposed by **Egido-Miguélez** (2015) as an extension of biplot methods to treat three-way data, offering the advantage that, instead of taking a consensus matrix as a reference, any of the individual matrices can be chosen and the corresponding trajectories studied. The three-way data of the matrix include:

- rows corresponding to universities
- columns corresponding to the indicators of each ranking
- the situation at various time points.

The dynamic biplot is developed in two stages:

- biplot analysis of the two-way data matrix for the reference year
- projection on the biplot graph obtained in the previous stage of the remaining time points to be studied, revealing their trajectory throughout different contexts.

The first step studies the multivariate correlations between variables and individuals, or both, while the second step captures the dynamic nature of the analysis.

The dynamic biplot technique can be applied using any factorization, but the best simultaneous representation of the trajectory of variables and points is provided by the *HJ-biplot*, as it can represent both types of elements with the highest quality (**Egido**-**Miguélez**, 2015). The *HJ-biplot* (**Galindo**-**Villardón**, 1986) simultaneously represents the universities and indicators from each ranking on a plane, where the similarity between universities is inversely proportional to the Euclidean distance between them. Meanwhile, the angles between indicators enable an assessment of the degree of covariation:

- acute angles indicate direct correlation
- obtuse angles indicate inverse correlation
- right angles indicate independence.

The length of the vectors approximates the standard deviation of the indicators.

The order of the orthogonal projections of each row marker onto a column marker approximates the order of each row elements (universities) in that column (indicator). The larger the projection of a point onto a vector, the more a university deviates from the mean of that variable.

The reference axes of the biplot plane on which the universities and indicators are represented are the principal components obtained as eigenvectors of the covariance matrix between indicators. The associated eigenvalues enable an assessment of the amount of information that each biplot plane explains (the explained variance). The angle that each indicator makes with the axis of factor 1 and 2 is known as the contribution of each factor to the variability of that indicator, whereas the sum of the two contributions determines the quality of the representation in the factor plane.

The analysis was carried out using *R* with the *dynBiplotGUI* package, created by **Egido**-**Miguélez** (2015). The dynamic biplot technique finds application in the field of economics, but to the best of the authors' knowledge, it has not been applied to analyze universities based on their performance in rankings.

Table 1. Universities included in the *ARWU* and *THE* rankings

ARWU	***THE***
Barcelona	*Pompeu Fabra*
València	*Autònoma de Barcelona*
Complutense de Madrid	*Barcelona*
Granada	*Autónoma de Madrid*
Autònoma de Barcelona	*Navarra*
Autónoma de Madrid	*València*
País Vasco	*Complutense de Madrid*
Politècnica de València	*Rovira i Virgili*
Pompeu Fabra	*Alcalá de Henares*
Santiago de Compostela	*País Vasco*
Rovira i Virgili	*Granada*
Politècnica de Catalunya	*La Laguna*
	Oviedo
	Politècnica de Catalunya
	Salamanca
	Santiago de Compostela
	A Coruña
	Carlos III de Madrid
	Castilla La Mancha
	Murcia
	Politècnica de València
	Sevilla
	Politécnica de Madrid
	Vigo
	Zaragoza

3. Results

For both international classifications, all the Spanish universities and their weighted indicators were analyzed. To provide an initial overview, the mean and rate of change of each university for each of the variables were calculated. The reference situation used to construct the biplot was set as the year 2020, corresponding to the most recent situation and, therefore, the most interesting for this study. The data for the reference period were centered and standardized.

In the *HJ-biplot* graphs, the indicators are represented by vectors, while the universities are identified by points, labeled by their abbreviated name. Table 1 presents the universities that were included in the two rankings over the 5-year period, ordered according to their position in 2020.

There are 12 universities classified in the *ARWU*, and 25 universities in the *THE* ranking. Therefore, it is easier for Spanish institutions to be included in the latter classification.

3.1. The *ARWU*

Table 2 presents the results for the indicators of the *ARWU* ranking in each year for each university, as well as their mean and rate of change.

Table 2. *ARWU* indicators, averages, and rates of change (2016-2020)

University	Year	Alumni	HiCi	*N & S*	PUB	PCP
Autònoma de Barcelona	2016	0.00	0.00	12.10	45.20	20.70
	2017	0.00	0.00	13.20	46.30	21.60
	2018	0.00	0.00	11.20	47.80	22.70
	2019	0.00	7.30	11.30	48.50	23.40
	2020	0.00	9.90	12.30	46.70	23.30
Average			3.44	12.02	46.90	22.34
Rate of change				1.65%	3.32%	12.56%
Autónoma de Madrid	2016	0.00	14.50	10.90	38.40	18.40
	2017	0.00	10.90	12.40	39.00	18.70
	2018	0.00	9.60	12.80	40.30	19.50
	2019	0.00	7.30	12.60	40.70	19.40
	2020	0.00	7.00	11.60	40.00	19.30
Average			9.86	12.06	39.68	19.06
Rate of change			-51.72%	6.42%	4.17%	4.89%
Barcelona	2016	0.00	17.80	12.00	50.60	19.90
	2017	0.00	15.40	12.30	51.00	20.40
	2018	0.00	27.10	12.50	53.30	23.20
	2019	0.00	24.30	13.30	51.30	21.90
	2020	0.00	22.10	12.90	50.70	21.70
Average			21.34	12.60	51.38	21.42
Rate of change			24.16%	7.50%	0.20%	9.05%
Complutense de Madrid	2016	19.20	0.00	9.10	42.30	13.20
	2017	19.00	0.00	9.80	41.90	13.50
	2018	19.00	0.00	12.20	44.00	14.50
	2019	17.70	10.40	12.60	43.90	14.90
	2020	17.20	9.90	11.00	45.10	15.30
Average		18.42	4.06	10.94	43.44	14.28
Rate of change		-10.42%		20.88%	6.62%	15.91%
Granada	2016	0.00	22.90	5.30	40.70	16.00
	2017	0.00	24.40	6.20	40.30	16.40
	2018	0.00	23.50	4.20	40.80	16.30
	2019	0.00	23.20	5.30	41.60	16.10
	2020	0.00	21.00	6.30	42.60	16.40
Average			23.00	5.46	41.20	16.24
Rate of change			-8.30%	18.87%	4.67%	2.50%
País Vasco	2016	0.00	0.00	9.20	36.40	14.40
	2017	0.00	0.00	11.70	37.30	15.30
	2018	0.00	9.60	12.20	38.10	16.60
	2019	0.00	0.00	11.60	39.20	16.40
	2020	0.00	7.00	12.50	38.80	16.90
Average			3.32	11.44	37.96	15.92
Rate of change				35.87%	6.59%	17.36%

University	Year	Alumni	HiCi	*N* & *S*	PUB	PCP
Politècnica de Catalunya	2016	0.00	14.50	8.00	27.70	15.80
	2017	0.00	0.00	6.40	27.70	14.10
	2018	0.00	0.00	6.00	27.70	14.20
	2019	0.00	0.00	6.70	28.20	14.60
	2020	0.00	0.00	4.50	27.80	14.40
Average			2.90	6.32	27.82	14.62
Rate of change				-43.75%	0.36%	-8.86%
Politècnica de València	2016	0.00	17.80	7.60	31.80	16.10
	2017	0.00	10.90	7.50	32.40	15.30
	2018	0.00	9.60	8.90	32.40	15.10
	2019	0.00	10.40	8.20	34.20	15.10
	2020	0.00	14.00	8.00	34.00	15.80
Average			12.54	8.04	32.96	15.48
Rate of change			-21.35%	5.26%	6.92%	-1.86%
Pompeu Fabra	2016	0.00	0.00	19.70	27.20	34.30
	2017	0.00	10.90	20.10	27.80	37.70
	2018	0.00	13.50	20.10	28.50	39.40
	2019	0.00	0.00	19.70	28.90	36.30
	2020	0.00	0.00	16.20	28.90	34.90
Average			4.88	19.16	28.26	36.52
Rate of change				-17.77%	6.25%	1.75%
Rovira i Virgili	2016	0.00	10.30	5.30	23.20	21.50
	2017	0.00	0.00	4.90	23.80	20.30
	2018	0.00	0.00	4.60	23.30	20.30
	2019	0.00	7.30	5.20	24.60	22.00
	2020	0.00	7.00	4.60	24.70	22.20
Average			4.92	4.92	23.92	21.26
Rate of change			-32.04%	-13.21%	6.47%	3.26%
Santiago de Compostela	2016	0.00	14.50	6.20	30.90	14.80
	2017	0.00	15.40	6.90	31.30	15.50
	2018	0.00	13.50	6.30	32.30	15.70
	2019	0.00	7.30	5.80	32.60	14.90
	2020	0.00	7.00	6.10	32.50	15.10
Average			11.54	6.26	31.92	15.20
Rate of change			-51.72%	-1.61%	5.18%	2.03%
València	2016	0.00	0.00	6.90	41.50	15.00
	2017	0.00	0.00	5.50	43.00	15.70
	2018	0.00	0.00	5.70	44.30	16.40
	2019	0.00	14.70	6.90	45.40	17.20
	2020	0.00	12.10	7.10	46.30	17.50
Average			5.36	6.42	44.10	16.36
Rate of change				2.90%	11.507%	16.607%

HiCi (highly cited researchers), *N* & *S* (*Nature* and *Science* articles), PUB (articles in *SCIE* and *SSCI*), PCP (size of organization).

The results presented in Table 2 show that the *Universidad Complutense de Madrid* was the only university that managed to achieve a position on the Alumni indicator with an average value of 18.42. The *Universidad de Granada* obtained the highest average on HiCi (23.00), the *Universitat de Barcelona* on PUB (51.38), and the *Universitat Pompeu Fabra* on *N* & *S* (19.16) and PCP (36.52). Regarding the rate of change of each variable, the uni-

> Global rankings have a great impact on the prestige and internationalization of universities. Universities that perform well in these classifications will have greater capacity to attract students and academics from other countries.

versities that suffered the greatest decreases were the *Autónoma de Madrid* and *Santiago de Compostela* on HiCi (-51.72%) and *Politècnica de Catalunya* on *N* & *S* (-43.75%). The greatest positive variations were recorded for the *Universitat de València* on PUB (11.57%) and the *Universitat Politècnica de València* on PCP (17.36%).

Table 3. *ARWU explained variance*

Axes	Eigenvalue	Explained variance	Cumulative variance
Axis 1	4.55	37.65	37.65
Axis 2	4.30	33.62	71.27
Axis 3	3.37	20.58	91.85

The information captured in the *HJ-biplot* is presented in Table 3. Three axes were retained because a very high accumulated inertia (91.85%) was achieved, being sufficient to characterize with some certainty the positioning of the universities in the *ARWU* ranking with respect to all the variables considered.

Table 4 presents the contribution of each factor axis to the variability of the ranking indicators. The variable related to academics with *Nobel Prizes* or *Fields Medals* could not be included because no Spanish university obtained a score on it.

Table 4. Contribution of each factor axis to the variability of the *ARWU* indicators

Variable	Axis 1	Axis 2	Axis 3
Alumni (alumni with *Nobel Prize* or *Fields Medal*)	153	6	801
HiCi (highly cited researchers)	708	1	185
N & *S* (*Nature* and *Science* articles)	0	918	11
PUB (articles in *SCIE* and *SSCI*)	755	155	7
PCP (size of organization)	266	600	26

Considering the contributions of each factor to the entries in each column, it was observed that all the variables could be interpreted in the factor plane 1–2 or 1–3, resulting in a good quality of representation. PUB and HiCi made a strong contribution to axis 1. Regarding *N* & *S*, axis 2 provided information of interest, while axis 3 made the greatest contribution to axis 3.

Figure 1 shows the *HJ-biplot* for the 2020 data matrix, providing the best possible knowledge regarding the reference. A strong and direct correlation is observed between HiCi and PUB, with the latter variable also covarying directly with *N* & *S* and Alumni. The only indirect correlation appears between the PCP and HiCi indicators. However, the latter variable related to highly cited researchers presented independence from Alumni and a very weak connection with *N* & *S*.

Regarding the ranks of the 12 universities analyzed, a good quality of representation was not obtained for only 2, which are thus omitted from the factor planes. Universities were positioned in different parts of the graph, establishing various groups based on the similarity between their characteristics.

The *Universitat de Barcelona*, the best-classified Spanish university in the *ARWU* ranking, showed high values on the HiCi and PUB variables, each with a weighting of 20% in the final ranking. This university appeared close to the *Universidades de València* and *Granada*, which were ranked second and fourth, respectively. If we compare these po-

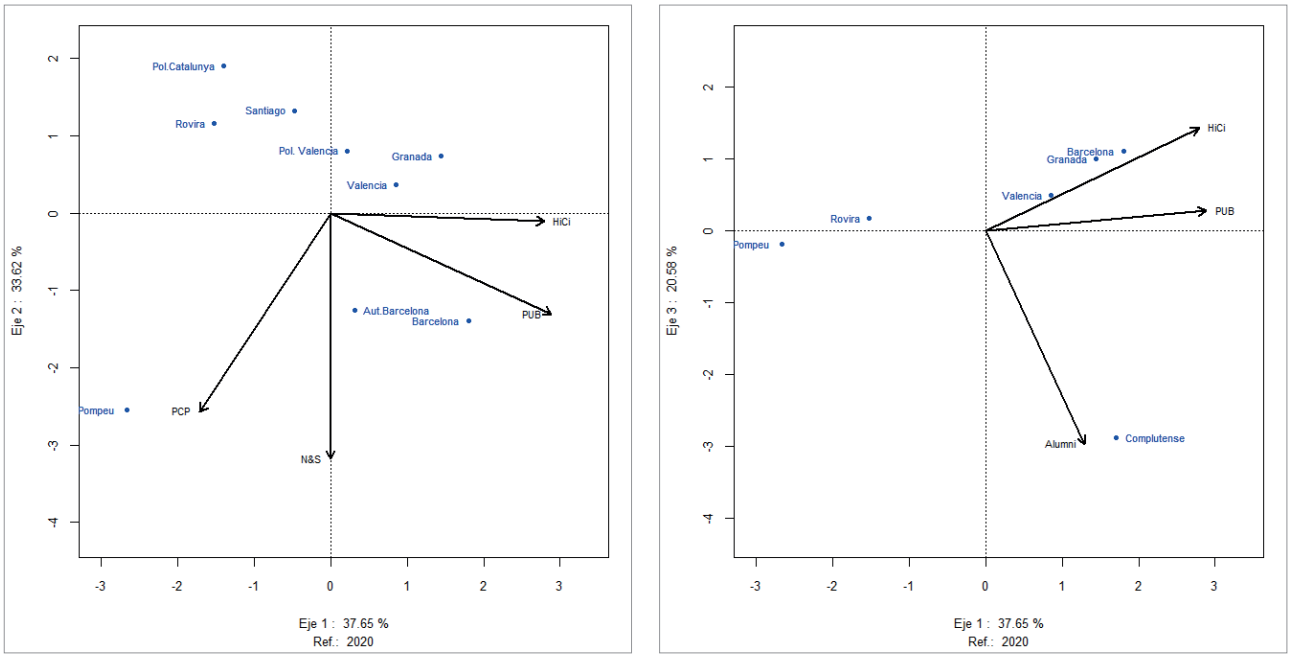

Figure 1. Factor representation *HJ-biplots* for the *ARWU* ranking (2020), planes 1-2 and 1-3.

sitions with the averages and rates of change presented in Table 2, it is observed that the *Universitat de Barcelona* obtained the highest average value on PUB (51.38) and the *Universidad de Granada* on HiCi (23.00). However, the *Universitat de València* obtained a low average on this latter variable (5.36) because it failed to make the ranking in the first 3 years. Table 2 also demonstrates that the *Universitat de Barcelona* exhibited its highest rate of change on HiCi (24.16%), while the *Universidad de Granada* experienced a decrease (−8.30%).

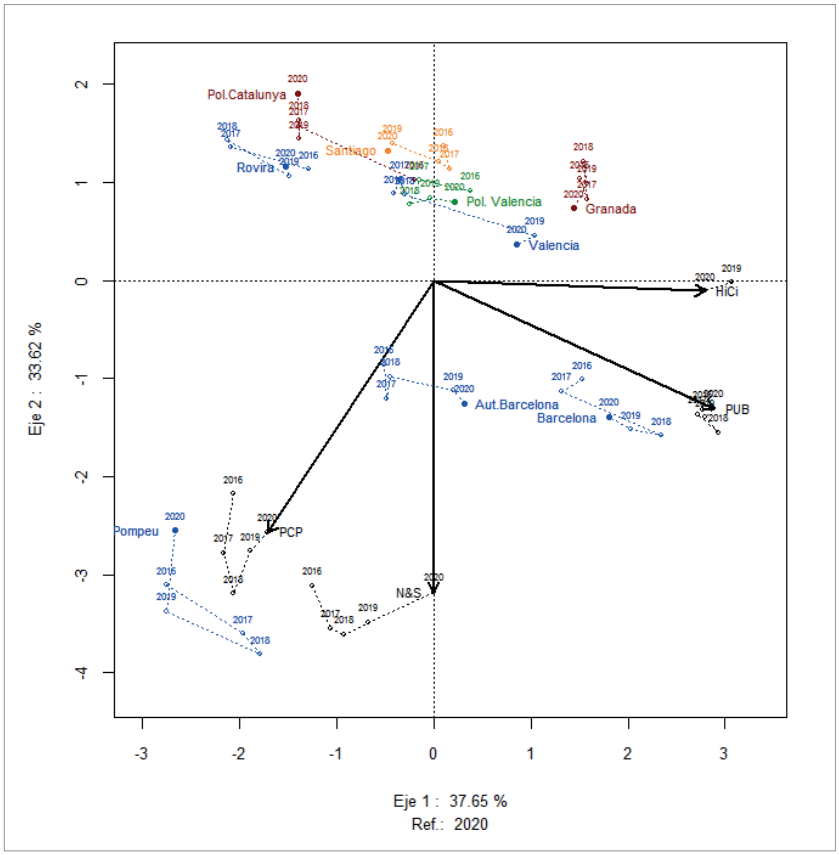

Figure 2. Dynamic biplot factorial representation of the *ARWU* ranking, plane 1-2.

Universitat Pompeu Fabra, ranked ninth, stood out for its high values on the PCP indicator, which includes the size of the organization, calculated as a weighting on all the variables. Its average was also very high (36.52) on this indicator (Table 2), although the rate of change was not significant (1.75%). The only university that stood out with high values for alumni with *Nobel Prizes* or *Fields Medals* (Alumni) was the *Universidad Complutense de Madrid*, ranked third in the final *ARWU* list. The *Universitat Autònoma de Barcelona* was included based on the number of published articles in *Nature* and *Science* (*N* & *S*), a variable with a weighting of 20% in the ranking. Table 2 demonstrates that its average on this variable was also high (12.02), albeit below that of the *Universitat Pompeu Fabra* (19.16), *Universitat de Barcelona* (12.60), and *Universidad Autónoma de Madrid* (12.06). The *Universitat Politècnica de València* was close to the highly cited researchers indicator, while the last three institutions listed (*Santiago de Compostela*, *Rovira i Virgili*, and *Politècnica de Catalunya*) all appeared far from the indicators shown, thus indicating low values. Table 2 shows that these three organizations exhibited significant decreases according to the rates of change of some of the ranking indicators.

Figure 2 shows the dynamic biplot, projecting the situation of each university in each year according to its trajectory.

The *Universitat de Barcelona* showed the greatest increase in the value of the PUB variable during 2018, with a reduction in the subsequent two years. The *Universitat Autònoma de Barcelona* showed the greatest variation in its trajectory in terms of the indicators, as it was characterized by PCP in 2016, 2017, and 2018 but approached *N* & *S* in subsequent years. The *Universitat Pompeu Fabra* showed an irregular trajectory but always characterized by the indicator related to organization size. Over the last two years, the *Universitat de València* showed considerable progress towards the highly cited researchers variable, thus approaching the *Universidad de Granada*, which exhibited a less pronounced trajectory. The other institutions generally showed trajectories that approached the variables but remained far from them.

> Global rankings are closely followed each by different stakeholders in higher education. Achieving a high ranking sparks great interest, even in Spanish universities

In plane 1–3, the *Universidad Complutense de Madrid* was always characterized by the Alumni variable.

3.2. The *THE* Ranking

Table 5 presents the results for the universities in the *THE* indicators for the different years, as well as the mean and rate of change for each.

Table 5. *THE* ranking indicators, averages, and rates of change (2016–2020)

University	Year	Teaching	Research	Citations	Industry	Internationalization
Alcalá	2016	17.60	11.20	28.30	43.30	50.00
	2017	19.60	11.50	31.80	42.20	55.80
	2018	20.40	12.20	45.90	40.50	59.80
	2019	30.40	14.50	37.50	41.00	61.60
	2020	18.50	15.70	43.20	42.50	59.00
Average		21.30	13.02	37.34	41.90	57.24
Rate of change		5.11%	40.18%	52.65%	–1.85%	18.00%
Autònoma de Barcelona	2016	40.30	40.00	83.80	34.90	50.30
	2017	39.40	36.40	86.70	39.90	52.30
	2018	43.30	36.10	89.50	42.10	60.10
	2019	43.90	36.50	92.40	41.30	62.20
	2020	40.90	36.10	92.90	44.80	64.30
Average		41.56	37.02	89.06	40.60	57.84
Rate of change		1.49%	–9.75%	10.86%	28.37%	27.83%
Autónoma de Madrid	2016	35.60	30.90	46.90	33.00	48.60
	2017	32.30	28.30	57.40	35.80	51.60
	2018	33.00	28.10	58.40	34.90	49.00
	2019	33.90	28.40	64.80	37.80	51.10
	2020	40.10	28.70	74.50	38.60	51.50
Average		34.98	28.88	60.40	36.02	50.36
Rate of change		12.64%	–7.12%	58.85%	16.97%	5.97%
Barcelona	2016	38.50	37.40	78.90	31.10	49.20
	2017	33.70	33.00	81.30	35.30	49.30
	2018	32.40	32.50	83.20	34.00	50.60
	2019	37.70	32.30	85.10	40.10	52.60
	2020	37.30	32.50	87.60	41.20	54.70
Average		35.92	33.54	83.22	36.34	51.28
Rate of change		–3.12%	–13.10%	11.03%	32.48%	11.18%
Castilla-La Mancha	2016	18.40	10.30	30.50	29.70	28.60
	2017	16.80	10.80	35.30	34.30	30.50
	2018	18.10	10.40	28.70	33.70	33.30
	2019	20.30	11.70	31.10	35.90	35.20
	2020	16.60	12.50	32.70	36.00	37.00
Average		18.04	11.14	31.66	33.92	32.92
Rate of change		–9.78%	21.36%	7.21%	21.21%	29.37%
Carlos III de Madrid	2016	23.20	17.40	24.80	34.80	44.70
	2017	24.70	15.90	29.60	37.20	53.10
	2018	24.60	15.30	33.60	36.30	56.80
	2019	26.40	16.00	37.30	37.80	58.60
	2020	24.40	16.30	34.90	38.20	60.20
Average		24.66	16.18	32.04	36.86	54.68
Rate of change		5.17%	–6.32%	40.73%	9.77%	34.68%

University	Year	Teaching	Research	Citations	Industry	Internationalization
Complutense de Madrid	2016	33.20	27.60	31.20	30.90	39.10
	2017	30.70	27.10	36.70	36.00	40.10
	2018	35.20	27.40	38.50	33.50	41.70
	2019	42.40	28.40	42.70	35.60	44.30
	2020	35.40	28.90	47.20	36.10	44.00
Average		35.38	27.88	39.26	34.42	41.84
Rate of change		6.63%	4.71%	51.28%	16.83%	12.53%
A Coruña	2016	18.30	10.00	16.60	38.20	23.40
	2017	17.60	10.90	23.70	35.50	27.30
	2018	19.10	11.20	23.70	34.30	30.60
	2019	22.80	12.40	26.10	35.60	30.90
	2020	20.30	13.70	32.50	36.30	31.60
Average		19.62	11.64	24.52	35.98	28.76
Rate of change		10.93%	37.00%	95.78%	–4.97%	35.04%
Granada	2016	24.30	14.70	45.80	29.40	36.40
	2017	21.90	16.80	46.30	33.20	43.10
	2018	22.50	19.20	46.80	32.80	50.10
	2019	23.50	19.00	48.30	35.00	47.00
	2020	19.40	20.90	52.00	35.60	48.10
Average		22.32	18.12	47.84	33.20	44.94
Rate of change		–20.16%	42.18%	13.54%	21.09%	32.14%
La Laguna	2016	16.90	10.00	44.80	28.50	44.70
	2017	16.90	9.60	48.50	32.70	47.10
	2018	18.10	9.70	57.50	32.40	46.60
	2019	24.30	11.50	62.30	35.10	46.70
	2020	19.30	11.50	67.80	35.20	46.90
Average		19.10	10.46	56.18	32.78	46.40
Rate of change		14.20%	15.00%	51.34%	23.51%	4.92%
Murcia	2016	19.30	11.70	28.00	29.50	28.30
	2017	18.40	12.70	31.00	33.50	32.00
	2018	20.10	12.40	32.10	33.00	34.70
	2019	27.40	13.20	32.20	35.30	37.60
	2020	22.30	13.80	32.60	35.90	38.50
Average		21.50	12.76	31.18	33.44	34.22
Rate of change		15.54%	17.95%	16.43%	21.69%	36.04%
Navarra	2016	31.90	20.80	57.50	63.50	52.60
	2017	29.70	23.90	65.30	55.60	55.60
	2018	27.90	24.50	74.60	63.90	59.70
	2019	34.10	24.20	82.00	66.60	63.20
	2020	30.40	27.90	80.30	85.50	65.10
Average		30.80	24.26	71.94	67.02	59.24
Rate of change		–4.70%	34.13%	39.65%	34.65%	23.76%
Oviedo	2016	19.50	10.80	41.90	34.10	36.20
	2017	18.30	12.40	44.20	33.40	30.50
	2018	27.00	13.50	49.10	34.10	31.90
	2019	25.50	14.70	50.80	38.00	34.10
	2020	16.80	15.20	54.80	38.50	34.40
Average		21.42	13.32	48.16	35.62	33.42
Rate of change		–13.85%	40.74%	30.79%	12.90%	–4.97%

University	Year	Teaching	Research	Citations	Industry	Internationalization
País Vasco	2016	18.20	19.60	43.10	30.30	34.90
	2017	20.90	14.30	50.20	34.70	37.90
	2018	21.00	14.80	51.40	34.80	40.80
	2019	20.40	16.50	50.00	36.20	40.10
	2020	22.00	17.10	47.30	37.10	41.50
Average		20.50	16.46	48.40	34.62	39.04
Rate of change		20.88%	–12.76%	9.74%	22.44%	18.91%
Politècnica de Catalunya	2016	25.20	14.80	44.70	40.90	63.90
	2017	27.10	17.50	51.20	41.50	51.40
	2018	27.10	17.60	55.30	41.60	53.20
	2019	29.70	17.30	53.70	40.90	56.20
	2020	23.70	17.20	56.90	41.20	59.10
Average		26.56	16.88	52.36	41.22	56.76
Rate of change		–5.95%	16.22%	27.29%	0.73%	–7.51%
Politécnica de Madrid	2016	21.80	14.60	24.50	38.30	39.50
	2017	21.90	13.70	30.80	39.10	41.90
	2018	23.80	13.60	34.80	43.00	45.00
	2019	31.10	13.90	37.90	42.60	47.50
	2020	22.60	14.90	37.70	42.40	49.10
Average		24.24	14.14	33.14	41.08	44.60
Rate of change		3.67%	2.05%	53.88%	10.70%	24.30%
Politècnica de València	2016	20.30	12.70	34.30	43.80	32.90
	2017	22.10	24.80	43.90	44.30	41.90
	2018	24.00	25.40	44.40	43.50	43.60
	2019	25.40	12.00	45.20	44.50	47.50
	2020	22.10	11.80	41.30	44.80	50.00
Average		22.78	17.34	41.82	44.18	43.18
Rate of change		8.87%	–7.09%	20.41%	2.28%	51.98%
Pompeu Fabra	2016	32.90	28.00	90.70	37.20	63.30
	2017	30.30	33.00	93.10	40.50	65.10
	2018	34.70	38.90	97.10	40.00	62.30
	2019	40.00	39.10	95.70	42.40	64.30
	2020	37.70	40.10	94.40	44.50	66.50
Average		35.12	35.82	94.20	40.92	64.30
Rate of change		14.59%	43.21%	4.08%	19.62%	5.06%
Rovira i Virgili	2016	20.80	14.80	66.90	30.90	41.50
	2017	21.50	15.80	72.10	35.20	45.50
	2018	22.20	17.20	76.40	34.50	47.70
	2019	24.20	20.20	76.20	36.00	49.10
	2020	23.70	21.00	67.60	36.60	51.10
Average		22.48	17.80	71.84	34.64	46.98
Rate of change		13.94%	41.89%	1.05%	18.45%	23.13%
Salamanca	2016	26.10	16.90	25.90	31.60	40.80
	2017	23.30	14.40	32.20	35.20	44.50
	2018	24.80	13.70	35.50	33.50	47.70
	2019	27.80	15.20	33.60	35.60	49.50
	2020	26.40	17.50	37.90	37.00	51.40
Average		25.68	15.54	33.02	34.58	46.78
Rate of change		1.15%	3.55%	46.33%	17.09%	25.98%

University	Year	Teaching	Research	Citations	Industry	Internationalization
Santiago de Compostela	2016	22.90	14.10	46.90	32.30	37.10
	2017	19.80	14.90	40.90	35.70	42.40
	2018	20.90	15.00	48.20	35.20	44.20
	2019	26.80	16.00	50.50	39.00	44.30
	2020	21.80	16.60	46.90	40.30	44.70
Average		22.44	15.32	46.68	36.50	42.54
Rate of change		–4.80%	17.73%	0.00%	24.77%	20.49%
Sevilla	2016	21.50	14.90	32.60	36.70	32.00
	2017	19.50	13.90	33.10	37.90	34.40
	2018	20.90	15.40	35.70	42.80	34.70
	2019	27.00	18.80	38.70	36.60	38.40
	2020	25.40	18.70	36.50	36.60	38.20
Average		22.86	16.34	35.32	38.12	35.54
Rate of change		18.14%	25.50%	11.96%	–0.27%	19.38%
València	2016	22.70	16.90	49.60	31.30	40.50
	2017	20.90	18.40	50.50	34.40	41.70
	2018	21.90	18.40	56.20	34.40	42.20
	2019	28.00	19.60	68.00	36.30	44.90
	2020	24.60	20.80	70.80	37.00	47.00
Average		23.62	18.82	59.02	34.68	43.26
Rate of change		8.37%	23.08%	42.74%	18.21%	16.05%
Vigo	2016	18.40	10.50	31.80	38.10	30.70
	2017	15.50	11.70	33.20	37.00	36.50
	2018	19.40	12.20	32.20	35.70	40.30
	2019	26.00	14.80	35.30	39.00	41.70
	2020	17.70	14.60	39.50	38.40	41.60
Average		19.40	12.76	34.40	37.64	38.16
Rate of change		–3.80%	39.05%	24.21%	0.79%	35.50%
Zaragoza	2016	20.10	12.70	49.50	36.70	33.50
	2017	20.30	12.50	49.70	38.60	35.10
	2018	20.50	12.30	50.80	37.10	37.60
	2019	27.90	12.40	47.70	38.10	37.00
	2020	22.00	13.40	43.80	38.60	39.40
Average		22.16	12.66	48.30	37.82	36.52
Rate of change		9.45%	5.51%	–11.52%	5.18%	17.61%

Table 5 shows that the *Universitat Autònoma de Barcelona* achieved the highest averages on teaching (41.56) and research (37.02). Likewise, the *Universitat Pompeu Fabra* obtained the highest averages on citations (94.20) and internationalization (64.30). In the variable related to industry, the *Universidad de Navarra* achieved the highest average (67.02) and rate of change (34.65%). The highest percentage rates of change for the remaining variables were for the *Universidad del País Vasco* on teaching (20.88%), *Universitat Pompeu Fabra* on research (43.21%), *Universidad de La Coruña* on citations (95.78%), and *Universitat Politècnica de València* on internationalization (51.98%).

The information captured in the *HJ-biplot* for the first two axes is presented in Table 6. Two axes were

Table 6. Explained variance, *THE* ranking

Axis	Eigenvalue	Explained variance	Cumulative variance
Axis 1	8.98	67.21	67.21
Axis 2	4.67	18.20	85.41

Table 7. Contribution of each factor axis to the variability of the indicators in the *THE* ranking

Variable	Axis 1	Axis 2
Teaching	764	117
Research	860	78
Citations	787	12
Industry	293	623
Internationalization	656	80

retained as a high cumulative inertia was achieved (85.41%), sufficient to characterize with some certainty the positioning of the universities in the *THE* ranking with respect to all the variables considered.

The first factor axis contained the greatest amount of information. Therefore, the horizontal gradient is the most interesting to explain the ranking of the universities according to this multivariate latent gradient.

Table 7 presents the contribution of each factor axis to the variability of the different indicators in this ranking.

Considering the contributions of each factor to the entries in each column, all the variables could be interpreted in the factorial plane 1-2 and showed a good-quality representation. Research, citations, teaching, and internationalization made a high contribution to axis 1. For industry, the variable related to knowledge transfer, axis 2 contributed the most information of interest.

Figure 3 shows the *HJ-biplot* for the 2020 data matrix. A direct and strong correlation was observed between the teaching and research variables, both of which contribute 30% to the classification. There was also a direct covariation between both of these variables and citations and internationalization. Therefore, four of the five indicators in the ranking, with a total weighting of 97.5%, correlated directly in the biplot. Industry also showed a direct interrelation with the rest of the indicators, except education, with which it did not show any connection. However, no indirect correlations appeared between any of the ranking variables.

Regarding the rows, 8 of the 25 universities analyzed were not well represented. Universities were positioned in different parts of the graph, and various groups were established based on the similarity between their characteristics.

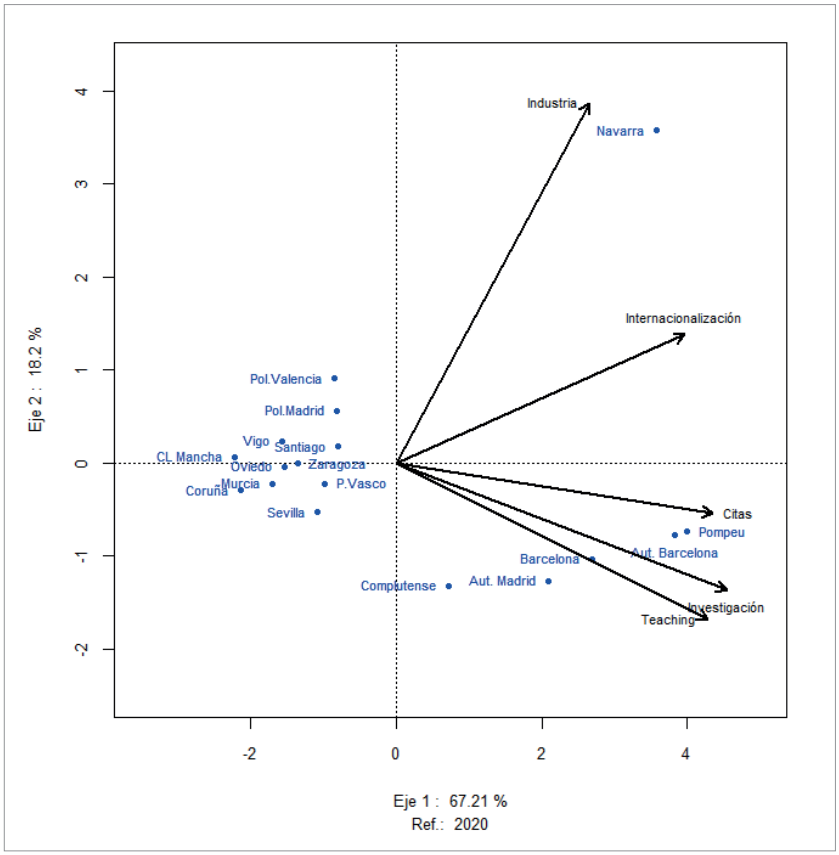

Figure 3. *HJ-biplot* factorial representation for the *THE* ranking (2020), planes 1-2.

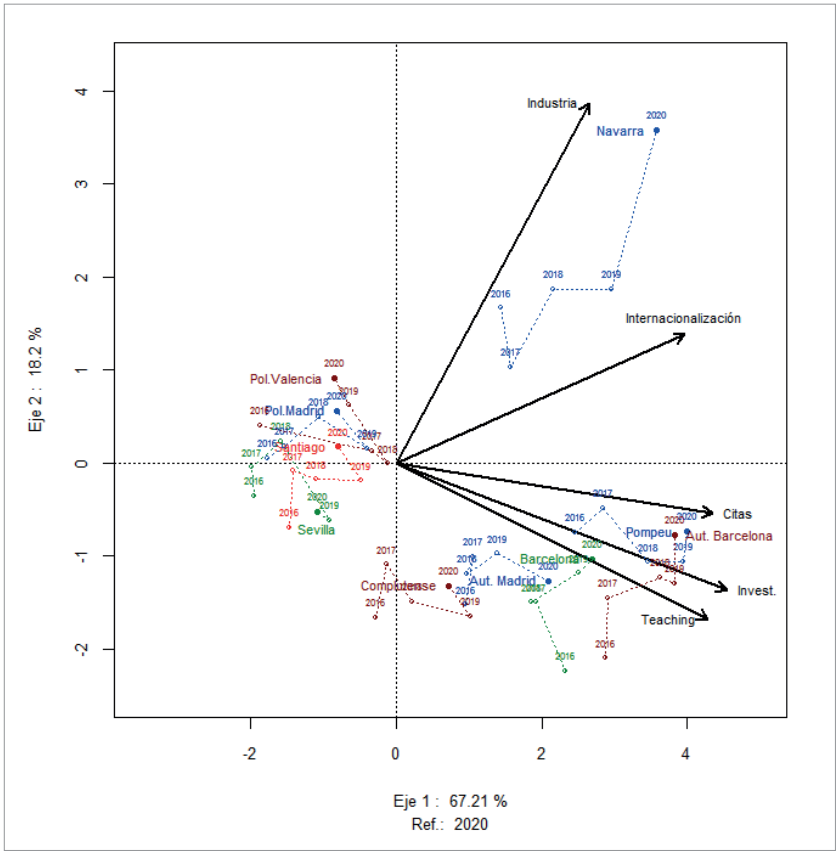

Figure 4. Dynamic biplot factorial representation of the *THE* ranking, plane 1-2.

The *Universidades Pompeu Fabra* and *Autònoma de Barcelona* were characterized by citations. *Barcelona*, *Autónoma de Madrid*, and *Complutense de Madrid* stood out in terms of the teaching variable, while the *Universidad de Navarra* obtained a high value on the industry variable. The other institutions are grouped in the left part of Figure 3, not showing good positions on any indicator of this ranking.

Comparison with Table 5 reveals that the highest means on citations corresponded to the *Pompeu Fabra* (94.20) and *Autònoma de Barcelona* universities (89.06), and although the rates of change were positive, they were not very high (4.08%, 10.86%, and 10.86%, respectively). The teaching averages of the universities of *Barcelona* (35.92), *Complutense de Madrid* (35.38), and *Autónoma de Madrid* (34.98) were high, but the highest value on this indicator corresponded to the *Universitat Autònoma de Barcelona* (41.56). Regarding the rates of change, the *Universitat de Barcelona* was the only university with a negative value (-3.12%). Finally, the *Universidad de Navarra* exhibited the highest average (67.02) and greatest increase (34.65%) on the industry variable.

> Twice as many Spanish institutions were classified in the *THE* ranking for five consecutive years compared with the *ARWU* ranking. In the *ARWU* ranking, no university managed to score in the category of academics who won a *Nobel Price* or *Fields Medals*

Figure 4 shows the dynamic analysis that enables a projection of the situations of the universities in each year, illustrating their trajectories.

The *Universitat Pompeu Fabra*, ranked first in the *THE* ranking, was characterized in 2016 by research, while in the following year it approached citations, only to stand out again in 2018 in research, and end again in 2020 with a high value on citations. The *Universitat Autònoma de Barcelona*, ranked second, also showed an upward trajectory that caused a change in its position from teaching to research, to end up characterized by citations in 2020. The trajectories of the next most highly classified universities, *Barcelona* and *Autónoma de Madrid*, approached teaching, which was also approached by the *Universidad Complutense de Madrid*. The *Universidad de Navarra*, after a decline in 2017 that brought it closer to internationalization, showed a growing trend towards industry with a very strong increase in the final year and a very distant position. The rest of the universities, albeit with changes in their trajectories, continued with more distant positions with respect to all the indicators.

4. Conclusions and discussion

This research demonstrates the practical utility of the dynamic biplot technique (**Egido-Miguélez**, 2015) to study the internationalization of Spanish universities through rankings, as well as to illustrate their trajectories. The *HJ-biplot* technique (**Galindo-Villardón**, 1986) facilitated a graphical representation of which universities and indicators could be superimposed in the same reference system with the highest quality of representation.

The present work examined the Spanish universities classified in the *ARWU* and *THE* rankings over the last five years. A very high accumulated inertia was observed for both lists, which allowed an intuitive interpretation of the graphs.

Different covariations were observed between the variables of the two rankings. In the *ARWU* ranking, the strongest direct correlation was found between two indicators weighing 40% each: highly cited researchers and articles indexed in *SCIE* and *SSCI*. This latter variable also correlated directly with published articles in *Nature* and *Science*, although more weakly. In contrast, highly cited researchers was indirectly interrelated with organization size and showed little covariation with articles in *Nature* and *Science* or alumni with *Nobel Prizes* or *Fields Medals*.

However, the indicators in the *THE* ranking appeared to be more linked, and none of them correlated indirectly, with only knowledge transfer not showing any connection with teaching. Furthermore, the three dimensions with the largest weightings (teaching, research, and citations) were strongly and directly correlated in the biplot. Likewise, these indicators showed a direct interrelation with internationalization, and therefore four of the five *THE* variables were correlated, together accounting for a weighting of 97.5% in this ranking. In line with these conclusions, **Safón** (2019) considered that international lists include reputation biases produced by surveys that affect not only teaching but also research performance. On the one hand, the editors of the most prestigious journals may be inclined to accept more articles from the most prominent universities. On the other hand, authors also tend to attribute a higher quality to works published from these institutions, increasing their citations. This ultimately means that research and reputation feed into each other, and the position in the rankings derives not only from the current results of the university but also from past reputation, which in turn improves current research (**Safón**; **Docampo**, 2020).

Twice as many Spanish institutions were classified in the *THE* ranking for five consecutive years compared with the *ARWU* ranking. In the *ARWU* ranking, no university managed to score in the category of academics who won a *Nobel Prize* or *Fields Medals*, a variable with a weight of 20% in the classification. The *ARWU* ranking exhibits a highly investigative component and measures outstanding individual performance through awards or highly cited researchers. Spanish institutions have limited production of this type (**Casani**; **Rodríguez-Pomeda**, 2017), thus hindering their positioning in this ranking.

> Rankings are not the only manifestation of internationalization, but competing in them brings with it prestige that is always beneficial for the organization as well as the reputation of the Spanish university system

> Spanish universities demonstrate a low level of internationalization, with only 29% appearing over 5 consecutive years (2016–2020) in the *ARWU* and *THE* rankings.

All the universities that managed to be classified in the *ARWU* ranking also did so in the *THE* ranking and are thus considered as centers with high transnational visibility. This visibility occurred through different variables. The category of highly cited researchers included the *Universidades de Barcelona*, *Granada*, *València*, and *Politècnica de València*. Only one Spanish university, the *Universidad Complutense de Madrid*, managed to score in the alumni *Nobel Prize* or *Fields Medal* winners category. Regarding knowledge transfer, the *Universidad de Navarra* stood out. No Spanish university was classified in the sole indicator that directly measures internationalization. The dimension valuing education, measured largely based on reputation surveys, included the *Universidades de Barcelona*, *Autónoma de Madrid*, and *Complutense de Madrid*. In this study, however, centers such as the *Autónoma de Barcelona*, *Pompeu Fabra*, and *Barcelona* stood out. The remaining 12 entities classified in the international lists did not obtain high values on any indicator and showed quite similar positions in the biplots.

It can thus be concluded that Spanish universities show a low level of internationalization, with only a small percentage having sufficient capacity to compete in global rankings. Only 29% of organizations appear continuously in one of the two most prominent and influential international rankings. Most of the universities have a weak brand with respect to the global context (**Carrillo**; **Ruão**, 2005), and only nine show high values on any of the indicators when considered in a multivariate fashion (*Autònoma de Barcelona*, *Autónoma de Madrid*, *Barcelona*, *Complutense de Madrid*, *Granada*, *Navarra*, *Politècnica de València*, *Pompeu Fabra*, and *València*). As more universities are added to these classifications each year, it will become necessary to analyze their trajectory over time to determine whether the prestige and reputation of the Spanish university system improve.

Although the concept of internationalization of higher education presents many nuances, and global rankings are not its only manifestation, one must not forget that they provide opportunities for greater transnational visibility (**Collins**; **Park**, 2016). All the research universities in the world follow them, worry about their orientation, and even adapt themselves in the face of methodological changes and transformations (**Pérez-Esparrells**, 2017). Competing in them brings with it prestige that is always beneficial for the organization as well as the reputation of the Spanish university system.

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