Barcelona's strength has been underpinned by innovative new research centres, such as the Barcelona Biomedical Research Park (PRBB).

SPAIN'S SCIENCE RIVALRY

Barcelona lures scientists while Madrid is bound by bureaucracy.

BY MONICA G. SALOMONE

In 2008, Barcelona replaced Madrid as Spain's most scientifically productive city. A decade on, the Catalonian metropolis is barely holding on to its lead as the capital struggles to recover from a financial slump that has left a substantial number of public research institutes on the brink of collapse.

Some scientists are concerned that the Catalan government's controversial referendum on independence from Spain could further erode Barcelona's advantage. The referendum was held on 1 October, despite being declared illegal by the Spanish courts.

In 2015, roughly 39.2% of Spain's research articles published in the Scopus database were produced by scientists in Barcelona, compared to 36.6% authored in Madrid. Barcelona remains slightly ahead despite having a little over half as many Spanish National Research Council (CSIC) centres as Madrid, and close to 2,000 fewer researchers.

The two cities face a tighter race to the top when it comes to the production of high-quality research tracked by the Nature Index. Since 2012, the two cities have been neck-and-neck, with a weighted fractional count (WFC), a measure of their contribution to paper authorship, hovering around 250. (Overall, Spain's WFC has declined from 1,191 in 2012 to 1,074 in 2016, with a slight increase in the past year.)

BY INVITATION

The key to Barcelona's success lies in a well-known formula, says Jaume Bertranpetit, at Pompeu Fabra University in Barcelona: "Attract as many first-class scientists as you can, make them feel comfortable, and let them do their job."

In the early 2000s, economist Andreu Mas-Colell, head of universities, research and information society for the Catalan government, devised a programme that would offer tenured positions to senior researchers from anywhere in the world. The Catalan Institution for Research and Advanced Studies (ICREA) was established in 2001 and now supports close to 260 professors — half of whom were working abroad at the time of hiring.

"MAKE THEM FEEL COMFORTABLE, AND LET THEM DO THEIR JOB."

In 2008, Catalonia's political parties signed a pact, with regional universities and trade unions, pledging to make the region a centre of research and innovation. Long-term support for ICREA was a key element of this agreement.

In 2016, each ICREA researcher brought in almost €300,000 (US$360,000), quadrupling the amount invested in them by the institution. Indeed, almost half of the European Research Council grants to Spanish scientists over the past decade have gone to Catalonia, close to 50% of which were awarded to ICREA researchers. According to Thomson Reuters, four of the world's most cited researchers in 2016, who have published many papers in the journals included in the index on topics ranging from quantum systems to autoimmune disorders, are among the scientists supported by the high-profile programme. The regional government recently set up a similar programme to recruit 500 new faculty members by 2020, specifically in public universities.

Another factor driving Barcelona's research performance has been the new research centres created by the Catalan government over the past decade, which operate under different working rules than most Spanish institutions. Whereas CSIC faculty are lifetime civil


FERRAN MATEO/PRBB

servants, hired through a sclerotic government application process, the recently established Research Centres of Catalonia (CERCA) have the freedom to create their own faculty positions that are subject to regular evaluation. The flexibility these centres offer in recruiting and paying staff salaries, as well as the administrative and funding support for setting up new labs, has appealed to international researchers.

Only a third of the group leaders at one of the CERCA centres, ICFO (The Institute of Photonic Sciences), are Spanish, which is a higher international share than in the CSIC centres. "They have all been hired for their scientific excellence," says physicist, Javier García de Abajo, an ICREA researcher at the institute, who recently published a paper in *Physical Review Letters* predicting a new type of physical force acting on nanostructures. The Barcelona Institute of Science and Technology, a multidisciplinary alliance of research centres within CERCA, ranked second in Spain in the Nature Index for 2016, after CSIC.

DROP IN CAPITAL

In Madrid at the centre of the country, the high density of CSIC centres that once contributed to the capital's scientific prominence has led to its relative decline.

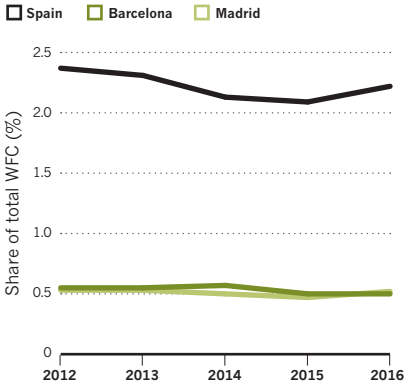
Severe cuts to science funding following the catastrophic global financial crisis of 2008 have starved the public research system. Between 2009 and 2013, the federal government slashed funding for CSIC by 32%. Following a brief reprieve, CSIC's budget saw a further cut of 0.9% in 2017. The council has made

BARCELONA
WFC 2016: 243
MADRID
WFC 2016: 252

	Barcelona	Madrid
Population[1]	1.61m	3.17m
GDP per capita[1]	US$34,000†	US$38,900‡
R&D as % of GDP[1]	1.5%†	1.7%‡
Number of researchers[1]	26,400†	28,200‡
Patents granted[2]	362	237

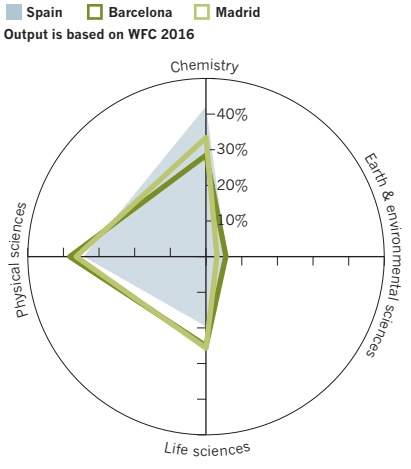
SHARE OF OUTPUT OVER TIME

City-level contribution to the share of authorship in the Nature Index, measured by the share of weighted fractional count (WFC) for that year, compared to Spain's share.



SUBJECT STRENGTHS

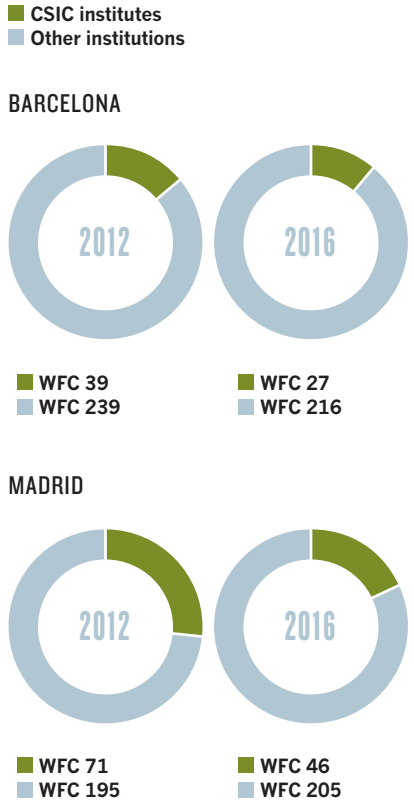
Researchers in Barcelona and Madrid contribute the most to physical sciences and chemistry papers in the Nature Index.



1. INE (National Institute of Statistics) (population 2016 data, GDP per capita 2016 data, R&D as % of GDP 2015 data, Number of researchers 2015 data)
2. United States Patent and Trademark Office (2016)
†Catalonia ‡Community of Madrid

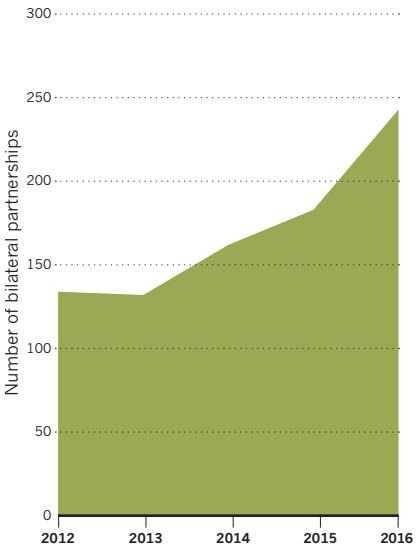
CSIC'S SHRINKING SHARE

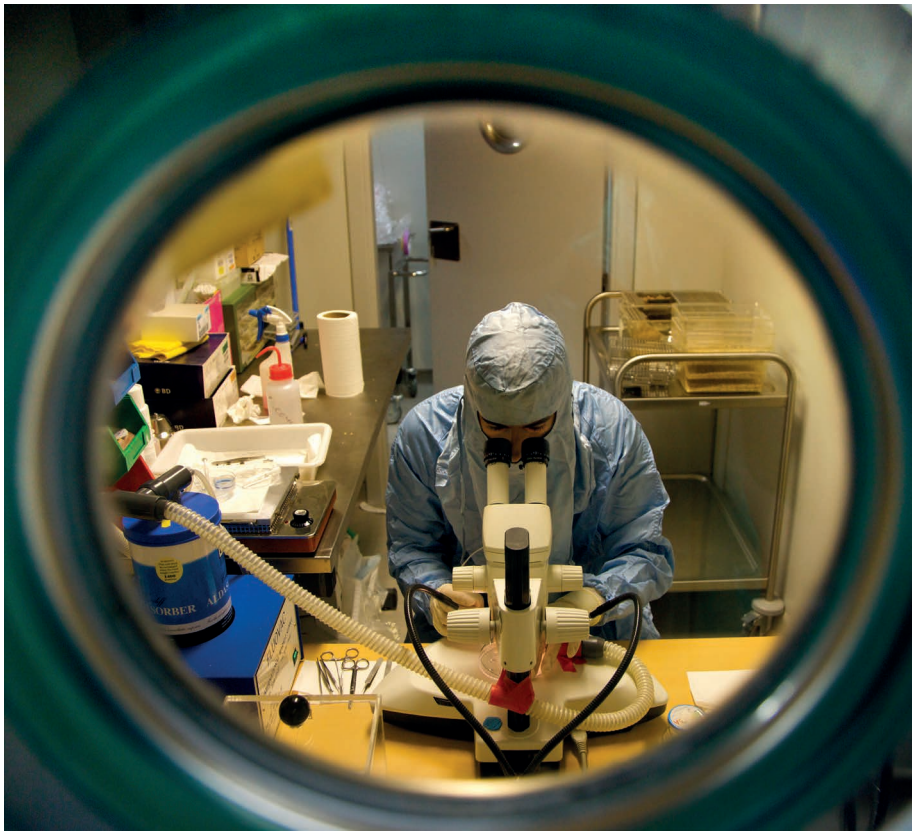
Spain's largest scientific organization, the National Research Council (CSIC), contributed to a smaller share of the authorship of papers included in the Nature Index in 2016 compared to 2012. The decrease, measured by weighted fractional count (WFC), is only slightly more pronounced in Madrid than in Barcelona.



BILATERAL COLLABORATIONS

The number of bilateral partnerships between an institution in Barcelona and an institution in Madrid has increased since 2012.





CSIC

The Centre of Biological Research is among a cluster of national CSIC institutions in Madrid.

thousands of employees redundant, and could see more losses as many of its scientists reach retirement age. "Only two of our group leaders are under 45," says Peter Klatt, a biochemist at the National Centre for Biotechnology, a CSIC institute in Madrid.

The talent drain from CSIC and established universities in Madrid has been largely buffered by the emergence of younger public institutions similar to those cropping up in Barcelona, which are less hampered by the government's rigid employment rules.

A third of the graduates and post-doctorates at the National Cancer Research Centre (CNIO), for example, are not Spanish nationals. According to the centre director, Maria Blasco, in the past five years, the centre has tripled its yearly income from royalties through its integrated drug-discovery programme and numerous agreements with big pharmaceutical companies.

In 2007, the Madrid regional government established the Madrid Institute of Advanced Studies (IMDEA), a group of seven institutes focusing on specific research areas, from water to food to nanoscience.

About 45% of IMDEA's budget comes from competitive grants — 60% of which are international — and the institutes have landed 12 European Research Council grants since their creation. While still small, IMDEA's WFC in the index more than doubled between 2012 and 2016, from 4.8 to 12.6.

Jose Manuel Torralba, director general of universities and research for the Madrid regional government, acknowledges the region's declining share of EU funds.

But, he says, a recent plan for research in Madrid — the first in eight years — will help to reverse the situation by increasing funding for science by as much as 50%, and introducing new types of contracts for young researchers and academic–industry collaborative projects.

SCIENCE AND POLITICS

Catalonia's referendum on independence from Spain has introduced another element of uncertainty to the city-level rivalry. Some researchers in Madrid and Barcelona admit, although not publicly, that the scientific environment has been strained by the prospect of a unilateral declaration of independence by the Catalan government.

Catalonia lacks an internal competitive grants programme to fund research, relying primarily on allocations from the national budget and international funding.

If it were to become an independent country, it is not clear whether it will belong to the European Union, and have the right to apply for grants with the European Research Council or under the larger Horizon 2020 programme. Other scientists argue that, on the contrary, the referendum will not thwart science in Catalonia precisely because it has become so international. ■

TOP 10 INSTITUTIONS IN BARCELONA

RANK	INSTITUTION	WFC 2012	WFC 2016	CHANGE IN WFC 2012–2016	AC 2016
1	University of Barcelona	70.4	61.1	–13%	407
2	Institute of Photonic Sciences, BIST	24.5	22.2	–9%	56
3	Catalan Institution for Research and Advanced Studies	20.1	21.6	8%	315
4	Autonomous University of Barcelona	43.3	19.7	–55%	333
5	Pompeu Fabra University	13.9	15.7	13%	72
6	Catalan Institute of Nanoscience and Nanotechnology, BIST	7.8	14.9	91%	46
7	Institute of Materials Science of Barcelona, CSIC	14.2	12.8	–10%	46
8	Institute for Research in Biomedicine, BIST	9.7	10.4	8%	42
9	Institute for High Energy Physics, BIST	3.2	9.2	187%	145
10	Polytechnic University of Catalonia	11.3	9.0	–20%	203

TOP 10 INSTITUTIONS IN MADRID

RANK	INSTITUTION	WFC 2012	WFC 2016	CHANGE IN WFC 2012–2016	AC 2016
1	Autonomous University of Madrid	67.5	72.5	7%	460
2	Complutense University of Madrid	43.5	36.9	–15%	201
3	Institute of Health Carlos III	21.4	14.1	–34%	128
4	Spanish National Cancer Research Centre	13.5	13.4	0%	33
5	Madrid Institute of Advanced Studies	4.8	12.6	166%	58
6	Institute of Materials Science of Madrid, CSIC	22.5	11.8	–47%	53
7	University of Alcalá	6.1	10.9	77%	55
8	Spanish National Center for Cardiovascular Research	3.5	10.6	201%	26
9	Technical University of Madrid	9.0	9.3	4%	39
10	Institute of Physical Chemistry "Rocasolano", CSIC	9.9	5.7	–42%	28

TOP 10 COLLABORATIONS IN BARCELONA

RANK	INSTITUTION 1	CS 1	INSTITUTION 2	CS 2	TOTAL CS
1	Institute of Photonic Sciences, BIST	17.53	Catalan Institution for Research and Advanced Studies	3.51	21.04
2	University of Barcelona	14.43	Catalan Institution for Research and Advanced Studies	5.77	20.20
3	Autonomous University of Barcelona	6.69	University of Barcelona	11.43	18.12
4	Polytechnic University of Catalonia	8.87	University of Barcelona	8.92	17.79
5	Pompeu Fabra University	8.23	Centre for Genomic Regulation, BIST	6.90	15.13
6	Polytechnic University of Catalonia	8.65	Institute of Space Sciences, CSIC	6.14	14.79
7	University of Barcelona	8.52	Institute of Space Sciences, CSIC	6.14	14.66
8	Autonomous University of Barcelona	5.99	Polytechnic University of Catalonia	8.65	14.64
9	Catalan Institution for Research and Advanced Studies	2.81	Catalan Institute of Nanoscience and Nanotechnology, BIST	10.94	13.75
10	Autonomous University of Barcelona	6.00	Institute of Space Sciences, CSIC	6.15	12.15

TOP 10 COLLABORATIONS IN MADRID

RANK	INSTITUTION 1	CS 1	INSTITUTION 2	CS 2	TOTAL CS
1	Autonomous University of Madrid	10.81	Madrid Institute of Advanced Studies	7.23	18.05
2	Autonomous University of Madrid	5.96	Complutense University of Madrid	5.22	11.18
3	Autonomous University of Madrid	6.06	National Institute for Aerospace Technology	3.17	9.24
4	Autonomous University of Madrid	1.30	Spanish National Center for Cardiovascular Research	4.91	6.21
5	National Institute for Aerospace Technology	1.95	European Space Astronomy Centre, ESA	3.73	5.69
6	Complutense University of Madrid	3.60	Madrid Institute of Advanced Studies	1.61	5.21
7	Autonomous University of Madrid	3.80	University of Alcalá	1.40	5.20
8	Complutense University of Madrid	2.81	Technical University of Madrid	2.03	4.84
9	Autonomous University of Madrid	1.47	Institute of Materials Science of Madrid, CSIC	3.17	4.64
10	Autonomous University of Madrid	2.05	Institute of Health Carlos III	2.48	4.53