Mathematics in Catalonia

A report of the
Catalan Mathematical Society

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1. Introduction

Scientific activity in Catalonia has increased significantly over the last thirty years, both in quantity and quality. This phenomenon is especially visible in mathematics, as noted by many mathematicians from all over the world, and as shown by the full range of bibliometric indicators.

The purpose of this report is to provide evidence illustrating that the scientific activity carried out in Catalonia is about as independent as it could be in any other European country. Although this notion, which appears in the Statutes of the International Mathematical Union in connection with membership, is to some extent ambiguous, it is fairly easy to define it in terms that appear reasonable and acceptable to a broad majority of scientists. A solid approach to this issue is founded on the following two basic pillars.

First, there should be a number of institutions created by a country's scientific community with the aim of conducting scientific activity at the local and international levels, including relationships with other scientific communities. These institutions should be well established, in the sense of having been operating for a substantial period of time and having an unquestionable influence on the country's scientific activity, wide support from the local scientific community, and international recognition.

Second, there should be a visible political structure which has drawn up and conducted its own scientific policy based on local considerations. This should include significant financial support of science and technology.

The current status of science in Catalonia, and of mathematics in particular, can be briefly described as follows. Around a century ago, an institution was founded with the aim of providing an academy covering both sciences and language, that is, an academic authority on the Catalan language. This institution is called the *Institut d'Estudis Catalans* (Institute for Catalan Studies, IEC). Nowadays the IEC is a non-governmental but publicly funded organisation. It is important to emphasise that the IEC is not structurally dependent on any other institution. It includes several scientific societies, among which is the *Societat Catalana de Matemàtiques* (Catalan Mathematical Society, SCM), founded in 1931. The SCM is very active in promoting mathematical activities of all kinds, from meetings about primary and high school mathematical education to research conferences at all levels. The SCM is an ordinary member of the European Mathematical Society and was entrusted with the responsibility of organising the Third European Congress of Mathematics in Barcelona in 2000. The existence of the IEC and, in particular, the SCM highlights the

independent nature of the research activity developed in Catalonia. On a more general level, the IEC and the SCM also exemplify the traditional vitality of the Catalan civil society, which has always included a dynamic network of many types of associations (cultural, sports, leisure, etc.), all with a strong commitment to the country.

Furthermore, Catalonia has its own government with wide-ranging executive powers, and one which has developed its own scientific policy through a series of four-year plans. Moreover, over the last twenty-five years, the Catalan Government has created a number of research institutions that have been charged with managing research at all levels. The executive action of the Catalan Government is based on the legislative activity of the Catalan Parliament, which has passed several laws regulating the educational system (including higher education) of Catalonia. Particularly relevant for the issue under consideration is the Law of Universities of Catalonia, a comprehensive regulation of all aspects of university life, including research and teaching posts.

It is of great significance that on March 1, 2006, the Parliament of Catalonia accepted, in its Committee of Cultural Policy, a statement agreed by all the parties represented in the Parliament urging the Catalan Government to support the Catalan Mathematical Society in order to strengthen and increase its international presence and representation.

Thus, the present report provides a concise account of basic facts concerning Catalonia and its mathematical activity, attempting to depict the shape and force of the Catalan mathematical community.

Two previously published summaries of reports on mathematical research activity in Catalonia over the past decade are appended at the end of this booklet, with permission of the editors of the IEC journal *Contributions to Science*, where these summaries first appeared. Such reports have been prepared by the IEC on a regular basis since 1990.

2. Mathematical Activity in Catalonia

2.1. Universities and research centres

In Catalonia, as in most countries, research in mathematics is principally done in universities. The most active Catalan universities in research terms are those that offer a degree and have a postgraduate programme in mathematics. These are the *Universitat de Barcelona* (University of Barcelona), the *Universitat Autònoma de Barcelona* (Autonomous University of Barcelona) and the *Universitat Politècnica de Catalunya* (Technical University of Catalonia). There are also active mathematical research groups in other universities, which offer degrees in disciplines that require background in mathematics. This is the case of the *Universitat Pompeu Fabra* (Pompeu Fabra University, Barcelona), the *Universitat de Girona* (University of Girona), the *Universitat de Lleida* (University of Lleida), and the *Universitat Rovira i Virgili* (Rovira i Virgili University, Tarragona). The departments of mathematics of Catalan universities employ around 400 mathematicians who conduct research and teach. Most of them regularly publish research articles covering all areas of mathematics, and some of them act as advisors to graduate students. Over the last thirty years, the amount and quality of mathematical production has increased significantly and nowadays Catalonia has reached an acceptable level in the international arena. More specific data are provided in the appendices, within reports on the status of mathematics prepared regularly by the Institute for Catalan Studies.

In this section, the most relevant mathematical activities carried out in Catalonia are reviewed, especially those emanating from universities and research centres.

CRM (*Centre de Recerca Matemàtica*)

The following concise presentation of the CRM is taken from the booklet that was published on the occasion of its twentieth anniversary in 2004.

The CRM was founded in 1984 by the Institute for Catalan Studies. Since 2002 it is an independent legal entity, in fact a consortium run jointly by the Institut and the Catalan Government.

The CRM is part of the Catalan network of research centres, which comprises some twenty research institutes. Together with the universities and the centres depending on state organisations, the network is one of the

pillars of Catalonia's scientific and technological system. Since 1997 the CRM has been a university research institute associated with the Autonomous University of Barcelona.

In the international frame, the CRM is a member of the ERCOM committee (European Research Centres on Mathematics) of the European Mathematical Society, and of the European Post-Doctoral Institute for the Mathematical Sciences (EPDI).

As for its scientific activities, the CRM invites outstanding scientists from around the world to conduct research visits, enabling young researchers to meet leading figures in their field and to build up contacts with other scientific institutions. The CRM also carries out research programmes and organises conferences, advanced courses, seminars and other scientific meetings, and disseminates the results of this research. Over its lifetime, the CRM has received continued support from the Catalan Government, the Spanish Government, the European Commission, and several private institutions.

From the very start, the CRM had a clearly defined raison d'être: it was to be a research institution available to Catalan mathematicians that would encourage top level mathematical research in Catalonia, both qualitatively and quantitatively. The Centre's interests were to range over all areas of mathematics, from the most basic to specific applications and from the teaching of mathematics to the design of financial tools, but especially fundamental research. For this reason, the CRM has sought to promote the fundamental vehicle for mathematics: the exchange of knowledge. This is its true laboratory. Only by understanding this need for communication, this need to create a structure in which experts can share their experience with those who are newer to the discipline, can mathematics evolve. Personal contact and interchange, and the breaking down of frontiers, are the mainstays of research and spread of knowledge. The CRM is proud of its internationalist outlook, a principle that reflects Catalan identity on the one hand and the universal nature of mathematics on the other.

During its first twenty years of existence, the CRM has welcomed 969 researchers from 58 countries for research stays. A total number of 3,480 researchers and doctorate students from 72 countries have participated in the CRM's activities: a small world, speaking more than 45 languages, has shared its scientific knowledge with the Catalan community. At the same time, visitors have had the opportunity to get to know Catalonia and have seen at first hand the high standard of scientific development. However, this internationalist approach to the exchange of knowledge would be of little use without the principle of equality. For this reason, the CRM has paid special attention to the needs of young researchers, from Catalonia and elsewhere, to facilitate contact with researchers already established in their fields and with institutions of prestige. It has promoted the full incorporation of women in mathematical research. Moreover, the CRM has taken particular care to facilitate the transmission of knowledge to those who live and work in less-favoured countries and enable their incorporation into international currents.

IMUB (Mathematics Institute of the University of Barcelona)

The IMUB was created in 2001 by the University of Barcelona. It is devoted to advanced research and training in any field of pure and applied mathematics. The aims of the IMUB are:

- To develop and support research in mathematics through the organisation of scientific activities, including advanced courses, workshops, conferences and seminars.
- To promote interdisciplinary work among researchers from different fields of mathematics.

The main fields of activity of the IMUB are: algebraic geometry, analysis, commutative algebra, differential geometry, dynamical systems, mathematical logic, number theory, statistics, stochastic calculus, and topology.

CIMNE (International Centre for Numerical Methods in Engineering)

The CIMNE is a member of the *Xarxa de Centres de Suport a la Innovació Tecnològica* (Network of Centres in Support of Technological Innovation) of the Catalan Government. It is an autonomous research and development centre dedicated to promoting and fostering advances in the development and application of numerical methods and computational techniques for the solution of engineering problems in an international context.

The CIMNE organises a wide range of activities aimed at the teaching and spreading of knowledge, such as courses, seminars, conferences and publications. Additionally, the CIMNE carries out various research and development activities and has participated in a large number of technology transfer projects in cooperation with over 150 enterprises and organisations from different countries.

The CIMNE publishes the following two journals:

- *Archives of Computational Methods in Engineering* (in English).
- *Revista Internacional de Métodos Numéricos para Cálculo y Diseño en Ingeniería* (in Spanish).

ICREA (Catalan Institute for Research and Advanced Studies)

The *Institut Català de Recerca i Estudis Avançats* (Catalan Institute for Research and Advanced Studies), widely known by the acronym ICREA, is a foundation jointly created in 2001 by the Ministry of Universities, Research and Information Society (DURSI) of the Catalan Government and the *Fundació Catalana per a la Recerca i la Innovació* (Catalan Foundation for Research and Innovation, FCRI). The main goal of ICREA is to promote scientific research in Catalonia in all fields of knowledge. The researchers

of ICREA are assigned to a university or research centre in Catalonia. They do not have teaching duties, although they may teach graduate courses if they wish to do so.

There are presently around 120 scientists in ICREA. The recruiting system of ICREA, based primarily on excellence and independent of the standard recruiting venues of the universities, has allowed several bright Catalan researchers working abroad to return home and help improve substantially the research system of the country. The list of ICREA personnel, which can be found at www.icrea.cat, features first-rank young mathematicians in the fields of logic, classical analysis and PDEs.

There is no counterpart of ICREA in the rest of Spain.

IDESCAT (Statistical Institute of Catalonia)

The Statistical Institute of Catalonia is an autonomous body, accountable to the Economic and Finance Ministry of the Catalan Government, which is specialised in statistical information. It is responsible for managing the Catalan Statistical System through planning, coordinating and standardising statistical activity, as well as by providing statistical technical assistance.

The Catalan Statistical System comprises all those institutions and bodies that perform statistical activities and which together produce the statistics in which the Catalan Government is interested, that is, official statistics. In addition to the Statistical Institute of Catalonia, the System includes the statistical services offered by the different ministries of the Catalan Government and those of regional public entities in Catalonia. It also covers those bodies and services which produce official statistics at the universities, institutes and university research centres, as well as chambers of commerce. Other public entities may have links to the Catalan Statistical System.

The IDESCAT produces economic, demographic and social statistics as the estimation of the gross domestic product of the Catalan economy, as well as Catalan population statistics (1996). It also follows up the execution of other statistical activities that take place in Catalonia. It is responsible for the dissemination of all official statistics produced in Catalonia, either by publishing them through the library or on the Internet, or by responding to requests addressed to the Institute.

As manager of the Catalan Statistical System, the IDESCAT is responsible for providing technical assistance to institutions, both in terms of production, analysis and dissemination of statistical data and with respect to the regulations on codes and statistical classifications, standardisation of operative definitions, probabilistic sample designs, etc., in order to increase the comparability and reliability of the statistical data.

Finally, mention should be made of the cooperation with other statistical institutions at the state and European level, the aim being to improve the quality and comparability of statistics.

2.2. International mathematical journals

Seven international journals in mathematics are published in Catalonia, two of which are general journals, two specialise in numerical analysis in engineering, one in fuzzy logic and soft computing, one in statistics and one in dynamical systems.

COLLECTANEA MATHEMATICA

This is the oldest journal in Catalonia, and in fact the oldest in Spain. It was founded in 1948 and aims to publish original research papers in pure and applied mathematics. It is published by the Mathematics Institute of the University of Barcelona (IMUB). Three issues, completing one volume (about 350 pages), appear on a yearly basis.

Starting in 2001, and as part of the celebration of the World Mathematical Year 2000, *Collectanea Mathematica* has undergone a major review by completely renewing its scientific committee, with some of the best specialists in all areas being brought on board.

PUBLICACIONS MATEMÀTIQUES

Publicacions Matemàtiques (formerly *Publicacions de la Secció de Matemàtiques de la Universitat Autònoma de Barcelona*) is published by the Mathematics Department of the Autonomous University of Barcelona.

Publicacions Matemàtiques is a journal publishing quality research papers in all fields of mathematics and, occasionally, expository surveys and proceedings of colloquia. The journal began in 1976, and in 1988 introduced a new format and a broader editorial board. Since then it has been able to combine good standards of published papers with moderate waiting time. Presently, the average publication delay is about seven months. A volume is published each year divided into two issues of approximately 250 pages each. It is indexed by the ISI Citation Index, where its impact factor can be consulted.

QUALITATIVE THEORY OF DYNAMICAL SYSTEMS

Qualitative Theory of Dynamical Systems is published by the University of Lleida. It publishes quality papers on the theory, methods and applications of dynamical systems in both discrete and continuous (ordinary differential equations) forms.

Papers submitted to this journal are carefully refereed. They should be accurate, original, non-trivial and of interest to a substantial number of readers. The journal publishes one volume each year consisting of approximately 250 pages.

SORT

SORT (*Statistics and Operations Research Transactions*) is an international journal published by the Statistical Institute of Catalonia (IDESCAT), appearing twice-yearly in English and aiming for the highest standards in methodological and applied research on statistics and operations.

The journal is co-sponsored by the Technical University of Catalonia, the University of Barcelona, the Autonomous University of Barcelona and the University of Girona, and is produced in cooperation with the Spanish section of the International Biometric Society.

SORT publishes original articles of a methodological or applied nature on statistics, operations research, official statistics and biometrics, as well as book reviews.

ARCHIVES OF COMPUTATIONAL METHODS IN ENGINEERING

The objective of the *Archives* is to provide a forum for disseminating results of research and advanced industrial practice in the broadly understood field of computational engineering, with particular emphasis on mechanics and its related areas.

A unique feature that sets this publication apart from other literature currently being published in the form of journals and books is that it aims exclusively to publish extended state-of-the-art reviews presenting detailed developments in selected areas of computational engineering. The articles are not mere literature surveys; a critical exposition of the topic in its full complexity will always be attempted.

Computational engineering is the leading theme of this publication. Specifically, it covers modelling, solution techniques and applications of computational methods in such areas as liquid and gas dynamics, solid and structural mechanics, bio-mechanics, multi-body system dynamics, stochastic processes, transport phenomena, heat transfer, coupled problems, control and optimisation, computer graphics, CAD/CAM etc.

Variational formulations and numerical algorithms related to implementation of the finite and boundary element methods, finite difference and finite volume methods and other basic computational methodologies form the core areas covered.

MATHWARE & SOFT COMPUTING

Mathware and Soft Computing is a journal edited by the Department of Computer Science and Artificial Intelligence of the University of Granada and the Mathematics and Computer Science Section of the Technical University of Catalonia.

Mathware and Soft Computing publishes two regular issues a year with an initial print run of 500 copies per issue. The journal is collected in

an annual volume comprising three issues: two regular issues and a monographic one for which a special editor is responsible.

Mathware and Soft Computing is a non-profit journal and is partially supported by the Technical University of Catalonia (UPC) and the European Association for Fuzzy Logic and Technology (EUSFLAT).

Its scope includes original papers, state-of-the-art contributions or short notes in areas such as approximate reasoning, fuzzy logic and functional equations applied to soft computing, logic, consensus, possibilistic reasoning and other fields.

3. The Catalan Mathematical Society

3.1. Presentation and main features

The *Societat Catalana de Matemàtiques* (Catalan Mathematical Society, SCM) aims to promote all aspects of mathematics in the territories where the Catalan language is official or normally used. It was born in 1931 as a section of the Catalan Society for the Physical, Chemical and Mathematical Sciences, which had been created by the Institute for Catalan Studies. In 1986, this earlier society split into three different societies. Nowadays, the SCM is one of the 26 member societies of the Institute for Catalan Studies. With more than 1,000 individual members, most of whom are researchers or teachers at one or other level of the educational system, it is one of the most active, prestigious, dynamic and influential among the scientific and scholarly societies affiliated to the Institute.

The SCM has been a member of the European Mathematical Society (EMS) since 1992. After a successful bid, it was entrusted by the EMS with organising the Third European Congress of Mathematics in Barcelona in July 2000. This was a major event, which gathered together more than 1,500 participants. The proceedings of this congress were published by Birkhäuser Verlag in the *Progress in Mathematics* series (volumes 201 and 202). Moreover, several Catalan mathematicians have held prominent positions within the EMS since 1997, including the chairmanship of the Publications Committee from 1998 to 2002 and the chairmanship of the ERCOM committee from 2003 to 2005.

Catalonia is listed as a participating country in the annual international contest *Le Kangourou des Mathématiques*, which is aimed at secondary school students. This is one of the activities of greatest impact organised by the SCM. Indeed, in March 2006 more than 15,000 students from Catalonia and Valencia participated in this event.

Four mathematical societies —*Real Sociedad Matemática Española* (RSME), *Sociedad Española de Matemática Aplicada* (SEMA), *Sociedad de Estadística e Investigación Operativa* (SEIO), and *Societat Catalana de Matemàtiques*— constituted the Spanish IMU Committee in 1998. As a member of this committee, the SCM actively collaborates in the development of several worldwide programmes or major events, such as the International Congress of Mathematicians (ICM 2006) in Madrid, or the World Digital Mathematics Library (WDML) programme.

The SCM organises activities of many kinds, publishes books and journals, awards prizes, and represents the Catalan mathematical community before educational authorities and other institutions, both at home and abroad. Some of the courses and lectures organised by the SCM are aimed at researchers, while others are geared toward secondary school teachers or a general mathematical audience.

3.2. Activities aimed at researchers

Since 1998, the SCM has organised an annual national scientific meeting, the venue changing from year to year. For instance, in 2000 it took place in Valencia. The 2003 meeting was held in Barcelona and was devoted to various aspects of the scientific work of Kolmogorov, on the occasion of the centennial anniversary of his birth. The 2004 meeting was linked with the Barcelona Universal Forum of Cultures. In 2005, the meeting was organised jointly with the Catalan Physics Society as a contribution to the World Year of Physics.

The SCM holds reciprocity agreements with several societies from outside Spain, including the American Mathematical Society, the *Société Mathématique de France* (French Mathematical Society) and the *Česká matematická společnost* (Czech Mathematical Society). Several joint events have been organised with some of these institutions. In 2005, the First Czech-Catalan Congress of Mathematics took place in Prague and gathered together more than 100 participants. In 2003, the SCM and the *Real Sociedad Matemática Española* jointly organised a two-day meeting on cryptography in Barcelona. The four Spanish societies (RSME-SCM-SEIO-SEMA) organised a major conference in Valencia in 2005, which served as an advertisement and a collaborative rehearsal for the ICM 2006.

The SCM awards an annual prize for students, which is given to the author of the best research or essay on a mathematical topic, usually at a postgraduate level. The Institute for Catalan Studies also awards a biannual prize in mathematics for the best PhD thesis written in Catalan, and an annual international prize (the Ferran Sunyer i Balaguer prize) for a mathematical monograph of an expository nature in English, and which presents the latest developments in an active area of research in mathematics in which the applicant has made important contributions. The prize, amounting to 12,000 euros, is financed by the Ferran Sunyer i Balaguer Foundation of the Institute for Catalan Studies. The winning monographs are published in the *Progress in Mathematics* series of Birkhäuser Verlag.

3.3. Activities aimed at secondary school teachers and students

In 1996 the SCM took part in the annual contest of the international association *Le Kangourou sans Frontières* for the first time. Currently, Catalonia is listed as one of the participating nations in the association's website www.mathkang.org/ksf/index.html.

This competition is aimed at students aged 14 to 18, and has become extremely popular in Catalonia, where the 10th anniversary of the event (jointly organised with Valencia and the Balearic Islands) was happily celebrated in 2005. In relation to the *Kangourou* competition, the SCM organises other activities aimed at secondary school students, namely, an online problem competition awarding a prize to the centre whose team answers all the questions in a minimum time, and a literary contest offering a prize for the best written text in Catalan with mathematics as its theme.

A selection phase for the International Mathematical Olympiad takes place every year in December in Barcelona. Since 2003 the SCM has also been responsible for the local organisation of the *Olimpíada Iberoamericana Universitaria de Matemáticas*.

There are several societies of mathematics teachers operating in Catalonia, all of which are encompassed by a federation known as FEEMCAT (*Federació d'Entitats per a l'Ensenyament de les Matemàtiques a Catalunya*). SCM and FEEMCAT now collaborate very closely on several issues. Since 2003, a joint meeting on mathematical education has been held every year in Barcelona, the aim being not only to gather together people interested in all levels of education (from primary school to university), but also to influence the Education Ministry of the Catalan Government. A representative of the Education Ministry participates every year in a round table within the SCM-FEEMCAT meeting, where the opinion of the Catalan mathematical community is heard. This should have an effect on the planning and quality of student curricula.

3.4. Publications

The *Butlletí de la Societat Catalana de Matemàtiques* is a journal devoted to mathematical research and high-level expository articles written in Catalan. A volume consisting of two issues is printed every year. Since 1996 the SCM has also published a newsletter called *Notícies* and, following the launch in 2005, a new series of monographs entitled *Publicacions de la SCM* is now freely offered in electronic format. The first volumes of this series include a geometrical study entitled «Estudis i activitats sobre problemes clau de la Història de la Matemàtica», aimed at secondary school teachers, and a translation of Gauss' «Disquisitiones generales circa superficies curvas» into Catalan. All volumes considered so far in this series are written in Catalan, although other languages are allowed.

3.5. Other activities

The SCM shares the main goals of the Institute for Catalan Studies, namely, to promote scientific research, in particular research related to all aspects of Catalan culture, while furthering the development of society in general and, when necessary, acting as an advisor to the Catalan Government and other institutions. In order to achieve this, and in addition to the main activities described above, the SCM organises yearly debates and lectures addressing different aspects of science and culture. On several occasions, SCM officers have led actions aimed at raising the profile of mathematics among the general public, especially during the World Mathematical Year 2000. The interest of the SCM in launching wide-ranging actions is illustrated by several events, the most recent of which was a Joint Mathematical Weekend held with the European Mathematical Society in September 2005 in Barcelona. More than 160 participants from a number of European countries attended this event, which reached an outstanding scientific level.

For more information, see the SCM website www.iec.cat/scm.

4. The Institute for Catalan Studies

4.1. Objectives, seat and sphere of action

The *Institut d'Estudis Catalans* (Institute for Catalan Studies, IEC), which was founded and enlarged on the initiative of Enric Prat de la Riba, in accordance with the agreements with the *Diputació Provincial de Barcelona* (Barcelona Provincial Authority) dated June 18, 1907 and February 14, 1911, is an «academic, scientific and cultural corporation the purpose of which is scientific research, principally that involving all the elements of Catalan culture». Thus is recognised in Royal Decree 3118 of November 26, 1976 and in the Resolution of the *Generalitat de Catalunya* (Autonomous Government of Catalonia) of May 17, 2001, whereby the Statutes, which contain the letter and the spirit of the founding agreements, were published.

- The Institut has its seat in the city of Barcelona.
- The Institut's officially recognised sphere of action covers the territories of the Catalan language and culture.
- The language of the Institut is Catalan.

In 1922 the Institut was admitted to the International Union of Academies (IUA), founded shortly before, and it has cooperated with different international research ventures and continues to do so.

The Institut has a long history, clearly delimited lines of action which have been honed over time, and a forward-looking ethos.

4.2. History

FOUNDATION

On June 18, 1907, by means of a recommendation-agreement signed by its president Enric Prat de la Riba, the Diputació Provincial de Barcelona decided to «create a new centre which might be named the *Institut d'Estudis Catalans*». The internal rules were approved by the Diputació on July 31, 1907.

Initially, the Institut was divided into four sections —«a) History, b) Archaelogy, c) Literature, d) Law»—, but very soon the possibility of «setting up new divisions» was added.

While the formal aspects of the foundation were yet to be decided, its objectives were perfectly clear: «the reestablishment and organisation of everything connected with the genuine Catalan culture». These goals obeyed the demands of public opinion which had been repeatedly voices, specifically during the sessions of the 1st International Congress on the Catalan Language held in October 1906.

The first eight fellows of the Institut were Guillem M. de Brocà —at 57 the oldest—, Jaume Massó i Torrents, Antoni Rubió i Lluch —elected first president at the age of 51—, Miquel dels Sants Oliver, Joaquim Miret i Sans, Josep Puig i Cadafalch, Pere Coromines and Josep Pijoan —at 26 the youngest— elected first secretary, although soon replaced by the Majorcan Oliver. The seat of the new institution was at the *Palau de la Generalitat* (then known as the *Palau de la Diputació*), taking up the rooms occupied until a short time before by the Provincial Court.

THE EARLY YEARS

From the very beginning the characteristics which have indelibly marked the spirit of the Institut stood out: scientific rigour, *catalanitat* («Catalanness») and openness. The Institut has been faithful to these principles throughout its long history, since the *Propòsits* (Proposals) published in the first «Yearbook».

While rigour and *catalanitat* are inseparably linked, openness to the world of Europe is the other cornerstone of the *Propòsits:* although «turning the gaze to the other side of the Pyrenees and comparing the general incoherence of so many of our disciplines with the organisation and many-sided impetus they receive in the leading countries of the world» may be discouraging, one will set out to «join the leaders» even though this is perhaps «an ambition too illusory to be fulfilled in the present generation». «The upcoming generation» should be «duly trained to do so».

Although right from the beginning Catalan has been the language of the Institut, and one of its objectives has been to standardise its use in the field of top-level research, all the Romance languages as well as German and English have also always been accepted in its publications as the languages of non-Catalan contributors. And this respect for each language, beginning, naturally, by restoring to the Catalan people their own language as a vehicle of scientific culture, has been maintained ever since. It is not therefore inaccurate to state that the criteria established as an integral part of the Institut's foundation have given it character throughout its eventful history.

The model followed by the Institut was that of the *Institut de France*, composed of five great academies. But the term «academy» was carefully avoided, since in Prat's opinion it was geared more towards glorificaton than to study; the terms «institute» or «section» were chosen, that is,

«working committee», «centre for scientific research». After a period of indecision, the term «section or division» came to prevail in view of the relative incongruity of an «Institute» composed of «Institutes». In short, Prat de la Riba proposed «completing the Institut d'Estudis Catalans with a Science Section and a Philology Section». Thus, by an *Expansion decree-agreement* issued by the Diputació Provincial de Barcelona on February 14, 1911, the Institut was formed by three divisions: the History and Archaeology Section, the Philology Section and the Science Section. This was the start of an extremely fertile period for the Institut and for Catalan scientific culture.

THE SCIENCE SECTION

The Science Section, «dedicated to research in the mathematical, physical and chemical, and biological sciences», also originally included philosophy, economics and the other social sciences. Thus, at the outset it had a physician (Miquel A. Fargas), two biologists (August Pi i Sunyer and Ramon Turró), a mathematician (Esteve Terrades), an economist (Pere Coromines), a zoologist (J. M. Bofill i Pichot) and a philosopher (Eugeni d'Ors).

The Section immediately undertook various publications: the «Arxius de l'Institut de Ciències» (Archives of the Science Institute; from Vol. XIII on, «Arxius de la Secció de Ciències»), «Flora de Catalunya» (Flora of Catalonia) by J. Cadevall, in six volumes (completed in 1923), and «Fauna de Catalunya» (Wildlife of Catalonia, several booklets on Malacology and Entomology published before 1939), directed by Josep M. Bofill i Pichot; «Notes d'estudi del Servei Meteorològic de Catalunya» (Study Notes of the Meteorology Service of Catalonia), directed by Eduard Fontserè; the «Treballs de l'Estació Aerològica de Barcelona i del Servei Tècnic de Paludisme» (Works of the Aerological Station of Barcelona and of the Malaria Technical Service); the «Memòries de la Secció de Ciències» (Papers of the Science Section), the «Collection of Physics and Mathematics Courses», directed by Terrades; the «Biblioteca Filosòfica» (Philosophy Library) directed first by Eugeni d'Ors and later by P. Coromines, etc.

What in 1911 «was yet to be done» was now being done: thanks to the work of the Institut, it can be said that science in Catalan was being cultivated in almost all its branches.

AFFILIATED SOCIETIES

From 1913 on the Institut established a series of affiliated societies. While the corporation was formed by a limited number of fellows through the affiliated societies, which were set up and developed under the Institut's guidance and with the same spirit, contact was made with the Catalan scientific community and its collective work stimulated. The *Societat*

Catalana de Biologia (Catalan Biology Society, 1912) and the *Institució Catalana d'Història Natural* (Catalan Natural History Institution, founded in 1899 and affiliated to the IEC in 1915), the *Societat Catalana de Filosofia* (Catalan Philosophy Society, 1923), the *Societat Catalana de Ciències Físiques, Químiques i Matemàtiques* (Catalan Society for the Physical, Chemical and Mathematical Sciences, 1931) and the *Societat Catalana de Geografia* (Catalan Geographical Society, 1935) were created in this period and bear witness to the activity of the Science Section.

SERVICES AND AMENITIES

Quietly the Institut went about setting up services, laboratories and research centres, which placed it on a European level; the Excavations Service, the Monument Conservation and Cataloguing Service, the Lexicographical Phonetics Laboratory, the Geological and Geographical Service, the Physiology Institute, the Barcelona Aerological Station (later the Meteorological Service of Catalonia) and the Experimental Psychology Laboratory were established and fostered by the Institut.

PROMOTION OF RESEARCH

Moreover, in order to stimulate research, in 1915 the IEC instituted a series of prizes, the list of which has grown continuously. From the first list of 1915, signed by A. Rubió i Lluch and Eugeni d'Ors, opening a competition for five prizes and announcing two more, to the «73th List of Prizes and Scholarships» of April 23, 2003 which opened a competition for thirty-two prizes and fourteen scholarships and announced a total of sixty prizes and fifteen scholarships, are eighty-two years of promoting research, interrupted only for extrascientific reasons between 1936 (25th list) and 1946 (two cyclostyled sheets; the 27th list corresponds to 1947).

PARTICIPATION IN INTERNATIONAL BODIES

The ongoing work of the IEC came to have wide resonance abroad, enabling it to take part in the life and activities of several international bodies. In 1910 the Institut cooperated with the *Junta para la Ampliación de Estudios e Investigaciones Científicas de Madrid* (Council for the Extension of Scientific Studies and Research in Madrid) in setting up the *Escuela Española de Roma* (Spanish School in Rome). In 1922, shortly after the establishment of the International Union of Academies, it was one of the institutions admitted to form part of this body and cooperated successively on a number of undertakings: «Corpus Vasorum Antiquorum», Dictionary of Medieval Latin, «Tabula Imperii Romani», «Forma Orbis Romani», supplements to the «corpora» of Greek and Latin inscriptions,

«Corpus Philosophorum Medii Aevi», «Corpus Vitrearum», corpus of the troubadours, etc. In 1926 the Institut helped to create the International Committee for Historical Sciences and, when this was reorganised, the Spanish Historical Sciences Association.

THE NEW SEAT

On March 30, 1931, under the presidency of the mayor of Barcelona, Count Güell, accompanied by J. Maluquer i Viladot, president of the Diputació, and J. Puig i Cadafalch, president of the Institut, «the two historical buildings —the *Casa de Convalescència* (Convalescent Home) and the *Hospital de la Santa Creu* (Hospital of the Holy Cross), in Carme Street», were handed over «to the Institut d'Estudis Catalans by the mayor of the city on behalf of the Council, so that all the services of the Institut may be installed in the former and the Library in the great halls of the Hospital». A splendid future was foreseen for the Institut: «Passing through these rooms which the Council is giving to us and which the Diputació will restore and adapt, one sees physicists, mathematicians, the great thinkers of the future, who alongside the scholars of the other disciplines will be the chosen ones of the great Catalan democracy», said Puig i Cadafalch at the ceremony.

THE INSTITUT TODAY

Three facts were of importance for the return of the Institut to its position as the leading scientific body in the *Països Catalans* (the Catalan-speaking territories of the old Kingdom of Catalonia-Aragon) after the long adversity period of Franco's dictatorship (1939-1976) in Spain.

First, Royal Decree 3118 of November 26, 1976, signed by King Juan Carlos I of Spain, granted «official recognition of the Institut d'Estudis Catalans as an academic, scientific and cultural corporation... the sphere of action of which shall extend to the lands of Catalan language and culture». The Institut had passed from the complete clandestinity of the forties to the semiclandestinity of later years and subsequent tolerated activity to full legality.

Second, the signature of the Convention with Barcelona City Council and the Diputació on July 12, 1977 reinstated the 1931 Convention and returned the *Casa de Convalescència*, its old seat, to the Institut. The Diputació has restored the building magnificently and, starting in October 1982, the IEC has gradually moved back into the building. At the same time the Diputació has granted an important annual subsidy. In addition, the other Catalan Provincial Authorities and several city councils —in particular the Barcelona Council— have provided financial backing. The Spanish Ministries of Culture and of Education and Science have also made contributions to infrastructure work. And mention must still be made of the contributions of private individuals and organisations such as Omnium

Cultural and the Noguera Foundation, which were allocated to specific activities.

And, last but not least, the inclusion of the Institut d'Estudis Catalans in the budgets of the Generalitat de Catalunya since 1980 —by means of direct allocations and, indirectly, through subsidies for courses and books, granted by the CIRIT— guaranteed the Institut the support of Catalonia's highest institution.

In recent years. the Institut has consolidated its role in the scientific community and in society in general and has gained a fresh impetus from the incorporation of new fellows. The Institut today may be said to bring together a large part of the scientific elite of the Catalan-speaking world, which leads to trust on the part of the public powers and shapes the role of an institution with a powerful influence on Catalan society. A good example of this influence is the publication, in October 1995, of the *Diccionari de la llengua catalana*, which clearly demonstrated the Institut's ability to accomplish what its statutes lay down with the highest standard of quality that can be called for. This work has met with a great public response, demonstrating the pressing need for such a work and its timeliness.

But the *Diccionari de la llengua catalana* represents only one part of the Institut's activity. The great lexicographical work of the twenties continues, with modern tools and methods, with the preparation of the *Corpus textual de la llengua catalana*, which gathers more than fifty million occurrences, duly categorised, which will make it possible to create new dictionaries with modern methods, and will be available to researchers for any type of research into the language.

The *Centre de Recerca Matemàtica* (CRM) is another example of the impetus of the Institut in recent years, at the same time taking up the tradition started by Esteve Terrades, who made it possible for scholars of the stature of Albert Einstein and Hermann Weyl to spend time in Barcelona. Every year the Centre welcomes foreign researchers in the field of mathematics.

With its divisions and affiliated societies, the Institut promotes and conducts research in the different fields of science and technology, but mainly in the area of all the elements of Catalan culture. First and foremost, the Institut is a centre for Catalan studies, working on wide-ranging projects such as the compilation of documentary corpuses and major critical editions.

The Institut has signed cooperation agreements with all the universities in the Catalan territories and with the *Consejo Superior de Investigaciones Científicas* (Higher Science Research Council). As a member of the International Union of Academies, it takes part in international projects promoted by the IUA.

The scientific activity of the Institut is reflected in the series of monographs and the journals published by the divisions and affiliated societies.

4.3. Present-day structure

GENERAL GOVERNMENT

The General Government consists of a Plenum, formed by all the fellows and affiliated society presidents, and a Standing Board, formed by: President, Vice-presidents, Secretary General, and Section Presidents.

DIVISIONS

History and Archaeology Section
Biological Sciences Section
Science and Technology Section
Philology Section
Philosophy and Social Sciences Section

AFFILIATED SOCIETIES

Catalan Institution of Natural History (1898)
Catalan Biological Society (1912)
Catalan Society of Philosophy (1923)
Catalan Physics Society (1986)
Catalan Chemistry Society (1986)
Catalan Mathematical Society (1986)
Catalan Geographical Society (1935)
Catalan Society of Historical Studies (1946)
Catalan Society of Judicial Studies (1995)
Catalan Economics Society (1977)
Catalan Sociological Association (1979)
Catalan Liturgical Society (1970)
Catalan Musicology Society (1973)
Friends of Romanesque Art (1977)
Catalan Society for Education (1979)
Catalan Classical Studies Society (1979)
Catalan Numismatics Society (1979)
Catalan Society for Territorial Planning (1979)
Catalan Society for the History of Education (1982)
Catalan Agricultural Studies Institution (1984)
Catalan Communication Society (1985)
Catalan Society for Language and Literature (1986)
Catalan Technology Society (1986)
Catalan Society for History of Science and Technology (1991)
Catalan Association for Food Sciences (1979)
Catalan Jewish Studies Society (1995)

For more information, see the Institut's website www.iec.cat.

5. Cultural and Political Background

5.1. Location

Catalonia is located in the northeast of the Iberian Peninsula and covers an area of approximately 32,000 km^2. Its population is about 6.7 million people. European countries of a similar area and population are Belgium (30,500 km^2 and 10.3 million people), Denmark (43,000 km^2 and 5.3 million people) and Switzerland (41,000 km^2 and 7.3 million people). Hungary has three times the area of Catalonia and a population of 10.1 million people.

The capital of Catalonia is Barcelona, whose metropolitan area has a population of 3 million people. Barcelona is widely recognised as a lively, cosmopolitan city with notable cultural, social and economic activity. Catalonia is one of the routes from the Iberian Peninsula into Europe, a fact that has shaped the country's history and personality.

5.2. Economy

The country's traditional structure of land ownership and the influence of Catalan law on such crucial matters as marriage, inheritance and the status of the principal heir (*hereu*) meant that the economic structure and development of Catalonia bears little resemblance to what happened in the rest of Spain. In particular, absentee landlords of large estates and the poverty arising from small landholding were largely unknown, while capital was accumulated for the investment essential for industrialisation to take place at the end of the 18th and early 19th century. This, together with the trading tradition of the Catalan people, dating back to the Middle Ages, largely explains the differences between the Catalan economy and that of other parts of the Iberian Peninsula.

Nowadays, primary industry, employing barely 3% of the labour force, hardly exists, while secondary industry includes a strong car and automobile accessory sector. The chemical industry is also strong. The traditional textile industry is still a force to be reckoned with, and there is increasing investment in the manufacture of domestic appliances and the latest generation of computer and telecommunications equipment. The graphic arts and the publishing industry are a key part of the Catalan

economy, as is the construction sector, which is growing hand-in-hand with the rise in tourism.

In the service sector, the main areas as far as GDP and employment are concerned are tourism and related activities. There is also a large number of companies linked to advertising, new technology and Internet content.

5.3. Brief history

Catalonia's formation as a political unit originated in a number of feudal counties in the area bordering the Carolingian Empire on the northern lands of the Iberian Peninsula conquered by the Muslims. Known as the *Marca Hispanica*, it was originally a feudal estate of the Carolingian Empire. At the end of the 10th century, the *Marca Hispanica* effectively became independent of the Franks. Catalan, the language of Catalonia, was born during these centuries and played a key role in creating among Catalans a sense of belonging to a distinct community. In 1137, the ruling families of Catalonia and Aragon were united by marriage, the ruler being the count of Barcelona Ramon Berenguer IV, who inherited the kingdom of Aragon. He defeated the last Arab strongholds between 1148 and 1153.

Jaume I el Conqueridor (James I the Conqueror) was responsible for Catalan expansion around the Mediterranean by conquering the island of Mallorca and the city of Valencia (1229-1238). During the course of the 13th and 14th centuries, the country became economically powerful (with maritime consulates in many Mediterranean ports) and politically strong (with the conquests of Sicily, Sardinia, the duchies of Athens and Neopatria, and, in the 15th century, Naples). The permanent committee of representatives at the Catalan Corts —one of the first parliaments in Europe— gave rise to the *Generalitat de Catalunya*, the country's government that was reinstated in the 20th century.

In the late 15th century, the marriage of Fernando II, King of Aragon and Count of Barcelona, to Isabel of Castile (also known in Spanish history as the Catholic Kings) brought about the monastic union with the kingdom of Castile. Catalonia preserved its political institutions and sovereignty (its own law, representative bodies, coinage, taxation system, etc.) right through to the early 18th century. The War of the Spanish Succession between the Bourbons and the Habsburgs resulted in the crowning of Felipe V as king, and was a serious defeat for Catalonia, which had sided with the House of Austria. The Decree of the New Regime brought about the abolition of Catalan institutions, laws and governing representative bodies, the prohibition of the public use of Catalan and the implementation of an absolutist strategy aimed at transforming Catalonia into a Castilian province.

The 18th century, however, saw an economic turnaround and the start of the country's industrialisation, which, beginning in 1832, became firmly established through steam-powered machinery and the predomi-

nance of the wool and cotton textile industry. The national restoration movements in Europe in the 19th century fostered the burgeoning cultural movement called *Renaixença* (Renaissance) and the revival of the Catalan language and literature. The vitality and influence of these cultural currents were so deep-rooted in Catalan society that they led to a new form of political activism known as Catalanism, one which has been highly influential ever since. Subsequently, it also led to artistic movements such as Modernism and the Avant-garde.

Under the Second Spanish Republic (1931-1939), the Generalitat de Catalunya was reinstated and the 1932 Statute of Autonomy was approved. However, defeat in the Civil War (1936-1939) resulted in Franco's dictatorship and the abolition of all Catalonia's rights and institutions. With the restoration of the Generalitat in 1977, a parliament and governing body for Catalonia were set up and a new Statute of Autonomy was approved in 1979.

5.4. Language and culture

Catalan culture is recognised internationally and the country's language, Catalan, has formed the basis of outstanding literature, in terms of both quantity and quality, from the Middle Ages to the present day. Other types of artistic production also deserve mention in Catalonia.

Catalan is a Romance language that was first recorded in written documents from the 12th century. Its original geographical sweep covered, in addition to present-day Catalonia, the region around Valencia, the Balearic Islands, Andorra (an independent state recognised by the United Nations), a small region in Aragon and a region in southern France (the Roussillon, which belonged politically to Catalonia until 1659). Nowadays, Catalan is also spoken in the city of Alghero on the island of Sardinia (Italy). Catalan is today the official language in territories inhabited by some 10 million people.

Catalan has always been used by Catalans in their family and personal relations. After 1714, when Catalonia lost its sovereignty following the War of the Spanish Succession, Catalan was prohibited and its use limited to the private sphere. Apart for the short period of the Spanish Second Republic (1931-1939), it was not until the Spanish Constitution of 1978 that the public use of Catalan obtained official authorisation. Indeed, the official status of Catalan, as provided for in the Constitution, is present in the Catalan Statute of Autonomy.

In spite of having been removed from political, legal, and educational life, Catalan remained alive as the main language of communication in Catalonia, it being the only language for oral communication in the country. Eventually, in the second half of the 19th century, the *Renaixença* movement brought about a fundamental change: the intellectual elite stated the common will of retrieving Catalan for high culture. A large number of renowned philologists, such as Pompeu Fabra (1868-1948) and

Joan Coromines (1905-1997), who for years held a professorship at the University of Chicago, organised Catalan grammar, vocabulary and spelling, and provided the language with a bibliographic corpus of the kind possessed by only a few other languages in the world.

This *Renaixença*, consolidated and updated during the 20th century, was the basis for a modern and prestigious literature, and many of its authors are regularly translated into English, French, German, Italian and Spanish. After the arrival of democracy and political autonomy in 1979 it has also been possible to normalise the use of Catalan at all levels of the educational system. At present, Catalan is being used from pre-kindergarten to university level, and all the usual educational tools are available, from text books to dictionaries and encyclopaedias.

Publishing in Catalan covers all literary genres, and includes translations of all kinds of works which have achieved international status, from Harry Potter books to winners of the Nobel literary prize and the great international classics. The Greek and Latin classics, as well as the classics of philosophy and science, have also been and continue to be meticulously translated and edited into Catalan. A measure of the weight and prestige of Catalan literature in the world is its presence in 2004 as guest at the Guadalajara Book Fair (Mexico), and the invitation to participate as guest of honour at the Frankfurt Book Fair in 2007.

Catalonia has perhaps acquired most of its international renown through art. Among the best known names, special mention should be made of the architects Josep Lluís Sert (1902-1983) and Antoni Gaudí (1852-1926), considered one of the most original creators in the 19th century and probably most widely associated with his design for the *Sagrada Família* in Barcelona; the musician Pau Casals (1876-1973), who lived in voluntary exile during Franco's dictatorship, and was the author of the United Nations peace anthem; and the painters Joan Miró (1893-1983) and Salvador Dalí (1904-1989), who renewed artistic language in the 20th century.

There is one other figure of Catalan culture who deserves an honorary mention: Ramon Llull (Raimundus Lullius, 1232-1316), poet and scholar whose original contributions in theology and knowledge theory proved to be of great influence in Europe in later centuries. His literary work was written in Catalan, and he translated many of his philosophical works into Catalan, too. This contemporary of Dante Alighieri provided Catalan with literary cohesiveness and flexibility, and turned it into a language for high culture, one which experienced a golden age in the 14th and 15th centuries.

In summary, Catalonia has a language of its own and a strong sense of national identity, and has developed a significant culture that differs from those of its neighbours, specifically Spanish culture. Catalan culture has been considered in detail from different viewpoints, two interesting reviews being «Nation building without a state» (Oxford University Press, 2001) by the Canadian sociologist Robert McKenneth, and «Barcelona» (Alfred A. Knopf, 1992) by the Australian historian Robert Hughes.

It should also be noted that Catalan is widely used at all educational levels. In primary education it is used to teach all subjects; in secondary education mathematical instruction is almost entirely taught in Catalan. At university, where Catalan is the official language of the administration, undergraduate mathematics are mostly taught in Catalan. Faculty and students in Catalan universities can use any of the two official languages, Catalan and Spanish, in any academic situation. In postgraduate studies, because of the presence of foreign students, Catalan and Spanish may be used alongside English, depending on the possibilities of faculty and students.

As far as research in mathematics is concerned, work is mainly published in international journals in English. However, some mathematical activities are published in Catalan: scientific reports, biographical and/or historical notes, articles on the teaching of mathematics and, generally speaking, all aspects related to the social activity of the Catalan mathematical community. Indeed, Catalan is the language used in publications of scientific societies such as the Catalan Mathematical Society. A large number of the PhD theses produced in Catalan universities were originally written in Catalan, with articles in English usually derived from them.

Finally, it is worth mentioning that the existence of a Catalan linguistic and cultural community is widely and increasingly recognised on the international stage. For instance, and as mentioned above, Catalan culture will be the guest of honour at the Frankfurt Book Fair of 2007. Furthermore, the International Committee for Assigned Numbers and Names (ICANN) has recently approved the domain «.cat» for individuals and private and public institutions pertaining to the Catalan linguistic and cultural community.

5.5. Political structure

In order to fully understand why mathematical activity in Catalonia has an independent nature, it is necessary to reach familiarity with some basic elements of Catalonia's political structure.

The Constitution of Spain was promulgated in 1978, three years after the end of a long dictatorship and during the consequent transition to a democratic regime.

Taking into account the history of Europe, and in particular that of Spain and Catalonia, the 1978 Constitution awarded Catalonia the right to its own government and a Statute to regulate its political powers. The Statute of Catalonia was promulgated in 1979 and currently functions as the system of basic principles and laws for the government of Catalonia.

The Statute re-established the government of Catalonia, known since the Middle Ages as the Generalitat, and the Catalan Parliament. Article 30 of the Statute reads as follows:

The Parliament represents the people of Catalonia and exercises the legislative power, approves budgets, supports and monitors the political action of the government and exercises the other powers attributed to it by the Constitution and, in accordance with the Constitution and with the Statute, by laws approved by the Parliament itself.

Article 33 states the following:

The Parliament of Catalonia will exercise legislative powers through the drafting of laws.

Over the last 25 years, the Generalitat and the Parliament of Catalonia have implemented their political powers in essentially all areas of public life, particularly in education and research. For instance, the Generalitat has drawn up a series of four four-year «Research Plans». The Third (2001-2004) and Fourth (2005-2008) Research Plans can be consulted in English on the website of the Ministry of Universities, Research and Information Society (DURSI), www.gencat.cat/dursi.

As the reader may ascertain, the above Research Plans are comprehensive projects aimed at supporting science, technology and innovation, and which cover all aspects of scientific activity.

Of particular importance with respect to mathematics is that the Research Plans provide special funds for research projects of consolidated and emerging groups. This once again illustrates the independent nature of scientific policy in mathematics (as part of science and technology). Of course, Catalan researchers may also obtain funds from other sources, such as programmes of the Spanish state and the European Union.

The Parliament has passed several laws regulating, for instance, the Catalan university system and the elementary and high school system.

In sum, the independence of mathematical activity in Catalonia is similar to that of a typical European state, such as Finland, The Netherlands or the Czech Republic, to mention just a few states whose population is of the order of that of Catalonia. However, there is one main difference that should be noted in order to have a clearer view of the actual situation, namely, that the Catalan scientific system is subject to three normative and complementary levels —rather than the usual two. These are the level of the Catalan Government and Parliament, that of the Spanish state and that of the European Union. For example, researchers in a typical European state obtain funds for their scientific projects from two sources: the programmes run by their own state and those run by the European government. In the case of Catalonia there is an intermediate level, namely, that of the Spanish state. As it turns out, the resources corresponding to the three levels are approximately comparable (see below the figures presented in the Research Report 1996-2002). Another example is that of legislative action. The activity of a university's scientific community in a typical European state is subject to both state laws and European regulations. In Catalonia, however, there is an intermediate level

consisting of the regulations originating in the Spanish state, which tend to establish only a normative framework.

However, in education and research there is nowadays a shift towards the creation of a European Space, namely, a European Education and Research Space whose aim is to make compatible different cultural and scientific traditions and promote mobility of students, teachers and researchers.

5.6. The university system

The management of the university system in Catalonia was formally transferred to the Generalitat in the 1980s, in compliance with the provisions of the Constitution and the Statute. At that time there were only three universities in Catalonia, all of them public. Now there are twelve universities, five of which are privately owned and run. The seven public universities are funded and supervised by the Generalitat. The Open University of Catalonia, as its name suggests, provides non-classroom higher education. It is also funded and run by the Generalitat, although formally it has the status of a private institution. Three public universities offer degrees in Mathematics and have their own PhD Programme in Mathematics. They are:

- *Universitat de Barcelona* (UB, www.ub.edu);
- *Universitat Autònoma de Barcelona* (UAB, www.uab.es);
- *Universitat Politècnica de Catalunya* (UPC, www.upc.edu).

Initially the responsibilities and powers of the Generalitat in higher education were ascribed to the Ministry of Education, but in the year 2000 the Ministry of Universities, Research and Information Society (DURSI) was created. This ministry runs the whole of Catalonia's university system. All large-scale decisions in university policy are the exclusive responsibility of the DURSI. This includes the creation of new public universities, new schools or new degrees in each university, the setting of tuition fees and the budget allotted to each university for its normal activity, the planning and financing of new investments, etc.

The Interuniversity Council of Catalonia is a relatively old institution (dating back to 1931) that coordinates Catalan universities. In addition to coordination on issues such as degrees offered, budgets and so on, it offers support on matters related to the relationships between Catalan universities and Catalan society, and particularly industrial and entrepreneurial networks. A report from this Council is mandatory before the DURSI takes many of its decisions on university policy. The Council also organises the admission process for new students at Catalonia's public universities; this process is run for these universities as a whole and is separated from non-Catalan universities (although a certain number of places are reserved for students coming from outside Catalonia).

The activity of universities in Catalonia is now regulated by the Law of Universities of Catalonia (LUC), which was passed by the Catalan Parliament in 2003; the document may be consulted (in Catalan) at the website www10.gencat.net/dursi/ca/un/luc_home.htm.

The LUC is a 65-page document which establishes comprehensive regulations covering the principles under which Catalan universities should function. It deals with a variety of subjects ranging from the goals of university activities to admission of new students, undergraduate and graduate fellowships, different kinds of degrees, organisation of and support to university research, technology transfer, duties and rights of students and lecturers, evaluation of teaching and research quality, coordination among universities, finances, staff recruitment, emeriti, etc. We shall try to convey briefly a general idea of the spirit of the law.

The first sentences of the preamble read as follows:

At the beginning of the new century Catalan universities face new realities, new challenges and new opportunities. The processes of internationalisation will have a profound effect on our university community and require well thought out policies and strategies in areas such as the quality of teaching and research, the mobility of students and lecturers and the move towards the creation of a European Higher Education Space.

After several considerations about the present evolution of the social and economic situation, one finds the following statement, which clearly synthesizes the foundations of the Law.

In seeking to face the new reality, this Law is founded on three premises. The first is the existence of a Catalan university system, heir to an intellectual, educational and scientific tradition of our own, and which we call the «University System of Catalonia». The second is the desire of this system to become part of the European Higher Education Area and play a relevant role in its construction. Finally, the third premise is the consideration of excellence as an indispensable tool for progress in all aspects of university activity, particularly in teaching, research and the transfer of technology and knowledge.

A novel feature of the LUC, which has no counterpart in the Spanish university system, is the regulation of teaching positions on two levels (corresponding approximately to full professor and associate professor, respectively); these adopt the form of permanent contracts rather than the classical Spanish system of civil servant posts. This will give the universities greater flexibility in shaping their own faculty according to their specific needs. These positions are open to applicants of all nationalities and will be allocated according to the principles of objectivity and merit.

The LUC also creates a new government agency (a merger between pre-existing institutions) called the «Quality Agency for the University System of Catalonia», whose purpose is the evaluation, accreditation and certification of quality in the context of the university system. In particular, this agency is responsible for producing reports regarding the allocation of temporary teaching positions, the accreditation of researchers, the accreditation of degrees in the framework of the European quality space, and the evaluation of the quality of teaching, management and other university activities.

The status of the Catalan language within the university system of Catalonia deserves special consideration (see also the section entitled «Language and culture»). Article 6 of the LUC reads as follows:

> *The universities of Catalonia have Catalan as their own language and, consequently, Catalan is the normal language in their activities. Catalan is the official language of the universities of Catalonia, along with Castilian.*

In the linguistic context Castilian is synonymous with Spanish, and is the original name for this language.

Catalan is nowadays the main language of everyday life in the universities of Catalonia. Classes are widely taught in Catalan and virtually all written communications in the university community are in Catalan. Most PhD dissertations are written in Catalan, although the role of English is increasing in this area. Of course, English is the language most frequently used in scientific seminars.

6. Conclusions

The information presented in the preceding sections can be briefly summarised as follows.

Catalonia comprises a well-defined linguistic and cultural community with ramifications in four European states: Andorra, France, Italy and Spain. The common linguistic and cultural heritage has led to the creation of many cultural and scientific institutions which already have a well-established tradition and receive wide support from local communities, as well as significant international recognition. This is particularly the case of the Institute for Catalan Studies (the academy of sciences of Catalonia and the highest authority on the Catalan language) and the Catalan Mathematical Society. The Catalan mathematical community is nowadays very active and seeks international visibility and representation, its aim being to make a real and efficient contribution to the task of promoting and disseminating mathematics around the world.

In addition, Catalonia has its own political institutions, which over the last 25 years have continued to devise and implement scientific policy based on the country's particular needs. These institutions share and support the bid to achieve direct international representation.

International representation of Catalan institutions is being progressively accepted: the Institute for Catalan Studies is part of the International Academic Union and the Catalan Mathematical Society is an ordinary member of the European Mathematical Society. The International Committee for Assigned Numbers and Names (ICANN) has recently approved the internet domain «.cat» for private and public institutions and individuals pertaining to the Catalan linguistic and cultural community.

APPENDIX A

Mathematics in Catalonia: 1990-1996

forum

Mathematics in Catalonia:1990-1996*

The aim of this article is to present the main conclusions of the Report on research in Catalonia for the area of mathematics**. The report was prepared by Joaquim Bruna, Marta Sanz, Joan de Solà-Morales and the author of this text, and published by the Institute for Catalan Studies in 1998.

In the report, scientific activity in the area of mathematics was measured essentially by examining two parameters: papers published in specialised journals and doctoral theses read. It should be recognised that a considerable amount of activity in the field of mathematics consists of applying existing knowledge to the resolution of practical technological problems that arise in particular companies. This kind of scientific activity was not measured in any way in the report due to the difficulty of obtaining objective data.

This article is divided into the following sections: human resources, scientific production, funding, research publications, research centres, and conclusions.

Human resources

Most research in mathematics is carried out at universities. In the academic year 1994-95, Catalan university instructors and fellowship holders in mathematics were distributed among 5 universities (the University of Barcelona, the Autonomous University of Barcelona, the Polytechnic University of Catalonia, the University of Lleida and the University of Girona) as indicated in Table 1.

During the period of the study, there was an increase in the number of teaching staff employed in the mathematics departments of Catalan universities. At the University of Barcelona, this increase was by a factor of 1.41; at the Autonomous University of Barcelona by a factor of 1.2; and at the Polytechnic University of Catalonia by a factor of 1.98. The University of Lleida and the University of Girona are not included here as they did not have mathematics departments in 1990.

Scientific production

Doctoral theses

Table 2 shows the number of doctoral theses read in the specified departments during the 1990-1995 period. In the case of UB, the source of these figures is the *report of activities* for these years; for the other universities, the figures are drawn from the corresponding research reports.

The doctoral theses read at the University of Barcelona (UB) and the Autonomous University of Barcelona (UAB) led to the granting of doctoral degrees in mathematics. We do not know if this was the case for the theses read in the departments at the Polytechnic University of Barcelona (UPC), the University of Lleida (UdL) and the University of Girona (UdG), given that, as a general rule, the universities grant doctoral degrees in areas in which they offer degree programmes. However, the 42 theses read at UPC are classified as corresponding to the mathematics area according to UNESCO codes. They should, therefore, be included in an analysis of mathematics research in Catalonia.

Table 1

	Stable teaching staff	Term contract teaching staff	Fellowship holders	Total
U. of Barcelona	75	23	11	109
Autonomous U. of Barcelona	48	32	11	91
Polytechnic U. of Catalonia	193	102	8	303
U. of Lleida	15	4	0	19
U. of Girona	13	12	1	26
Totals	344	173	31	548

Figures in this table include only teaching staff in mathematics departments. If mathematicians hired by other departments were counted, the total number of mathematicians in the universities would be 570.

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Relationship between stable personnel and theses read: the number of theses read in the 1990-1995 period must be examined in relation to the number of researchers available to act as thesis supervisors. We have introduced the index *T*

Table 2. Doctoral theses read in mathematics departments at Catalan universities. 1990-1995 period

University of Barcelona	
Dept. of Applied Mathematics and Analysis	12
Dept. of Algebra and Geometry	9
Dept. of Statistics	9
Dept. of Logic, History and the Philosophy of Science	10
Total	40
Autonomous University of Barcelona	
Dept. of Mathematics	29
Total	29
Polytechnic University of Catalonia	
Dept. of Applied Mathematics I	4
Dept. of Applied Mathematics II	7
Dept. of Applied Mathematics III	11
Dept. of Applied Mathematics and Telematics	8
Dept. of Statistics and Operative Research	12
Total	42
University of Lleida	
Dept. of Mathematics	4
Total	4
University of Girona	
Dept. of Information Science and Applied Mathematics	3
Total	3
Total theses read: 118	

Table 3. Relationship between theses read and stable personnel

		UB	UAB	UPC
$T = $	$\dfrac{\text{Theses read 90-95}}{\text{Stable teaching staff}}$	0.75	0.96	0.72

to indicate the relationship between theses read in the 1990-1995 period and stable personnel for the academic year 1989-90.

Scientific publications

We have used the database of the journal *Mathematical Reviews* to analyse the publication of research papers in mathematics produced in Catalonia for the study period. This journal is published by the American Mathematical Society (AMS) and includes reviews of almost all mathematics papers published around the world. It must be borne in mind that on average slightly more than a year passes between the publication of a given paper and the appearance of the

corresponding review in *Mathematical Reviews*. If we also consider the fact that two or three years may pass between the time that a paper is sent to a journal and its publication, it is clear that the review of a paper appears three to four years after its production. We will analyse papers that were reviewed in the 90-96 period (which were produced three or four years before).

The total number of papers produced by authors associated with Catalan institutions and reviewed in *Mathematical Reviews* in the 90-96 period is 1429. The total number of reviews of publications globally for this period is 355916. Catalan production in mathematics represents 0.4% of global production (bear in mind that Catalonia has 0.11% of the global population).

Table 4 compares the total production of mathematics papers in the 1990-96 period with the production of other countries.

A certain degree of correlation between the last two columns of Table 4 can be observed («Number of papers/population» and «GDP/population»). Figure 1 offers a clearer view of this correlation.

The horizontal axis represents GDP/population and the vertical axis number of papers/population. Each country in Table 4 corresponds to a point on the graph (indicated by a small square). Catalonia is represented by a slightly larger square to distinguish it better from the other countries. To identify any country represented in the graph, keep in mind that the order of the countries in the table corresponds to the order of its ordinates from the largest to the smallest in the graph. For example, Canada, which is the first country in the table, corresponds to the highest ordinate point in the graph. The cloud of points on the graph, corresponding the totality of countries considered, has a determinate form that is certainly not linear. The curve that appears in the graph corresponds to the graph of the third degree polynomial that best approximates the cloud of points by the minimum squares method. Observation of the curve reveals that as per capita GDP increases, the production of mathematics papers per person increases, but that the rate of increase in
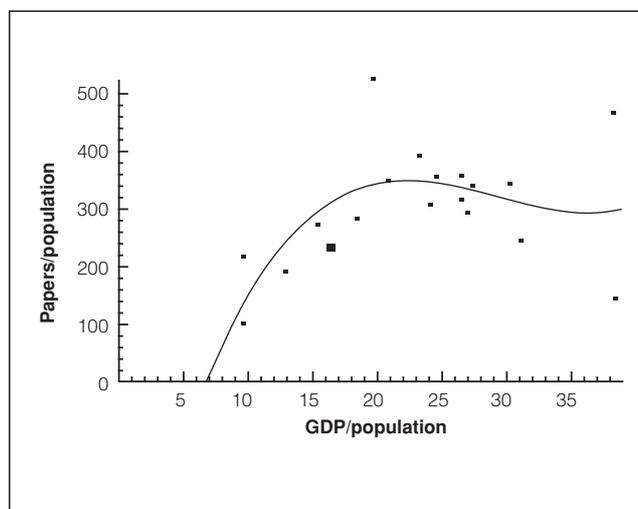

Figure 1. Comparison of countries. Total papers.

Table 4. Comparison of countries - total papers

Country	1995 population	1995 GDP	Total number of papers	Number of papers/population	GDP/population
Canada	29.6	586.6	15667	529.29	19.82
Switzerland	7.04	270.4	3301	468.89	38.41
Netherlands	15.45	361.6	6095	394.50	23.40
Belgium	10.11	269.2	3634	359.45	26.63
France	58	1432.1	20749	357.74	24.69
Finland	5.11	107.3	1805	353.23	21.00
Denmark	5.23	158.7	1811	346.27	30.34
United States	263.2	7246	90321	343.16	27.53
Austria	7.97	212.4	2544	319.20	26.65
Sweden	8.83	214	2728	308.95	24.24
Germany	81.6	2207.8	24165	296.14	27.06
United Kingdom	58.3	1080.1	16664	285.83	18.53
Italy	57.2	885	15717	274.77	15.47
Norway	4.36	136.3	1074	246.33	31.26
Catalonia	6.1	100.7	1429	234.26	16.51
Greece	10.45	102	2291	219.23	9.76
Spain (excluding Catalonia)	33.1	430	6408	193.60	12.99
Japan	125.1	4818.4	18366	146.81	38.52
Portugal	10.8	103.2	1084	100.37	9.56

In this table, the 1995 population is given in millions of persons and the 1995 gross domestic product (GDP) in billions of US dollars. The total number of papers refers to those reviewed in *Mathematical Reviews* during the period 1990-96. The column «Number of papers/population» indicates the number of mathematics papers published per million population. The column «GDP/population» indicates thousands of US dollars of GDP per person (quotient of the columns for GDP and population). The countries in the table are ordered according to the figures for the column «Number of papers/population» from greater to lesser. Catalonia (234.26) is below most of the countries in the table, and ahead of only Greece, Spain (excluding Catalonia), Japan and Portugal. It should be noted that the countries in the table (to which Catalonia is compared) are highly developed. The extremely low production of mathematics papers for Japan is very surprising. The United States is in the mid-area of the table. It should be kept in mind that these figures refer to the total number of papers published: they do not take into account the quality of these papers, which we will examine in section *Analysis of quality of publications*.

papers produced diminishes as GDP increases. The slight decrease in the number of papers after a certain level of GDP is not real: it is caused by the extreme data for Japan, which affect the form of the final part of the curve. The square representing Catalonia is below the graph curve, which indicates that production of mathematical papers is low in relation to that which would be expected for its level of GDP. It can be observed, though, that the United States is very close to the curve. The U.S. is, therefore, at a level of production that corresponds to its GDP (but not much above that level).

Analysis of quality of publications

In the preceding section, we have considered all papers published of mathematics research in Catalonia and the world, taking into account only the quantity, not the quality of these papers. We will now turn our attention to the quality of production.

One indicator of the quality of a scientific paper is the influence that it has on the subsequent development of the science: the number of times that the paper is cited by other authors provides a measure of this influence. Citations of good mathematics research papers may continue to occur over a very extended period. In this respect, the field of mathemat-

ics is distinct from other branches of the sciences: the initial impact of a publication may be less, but its influence can be extremely long-lasting. Bearing in mind these considerations, we have concluded that a methodology involving counting of citations would not be an appropriate approach for measuring the quality of mathematics research papers published in such a recent period. Lacking any better alternative, we have chosen to use an indirect measure of the quality of papers: the level of prestige of the journal in which they are published. Needless to say, this approach may fail to consider papers that have a high level of intrinsic quality and have had (or may yet have) a major impact on later work. From a statistical perspective, however, as a measure not of the quality of work done by a particular researcher or research group, but of that done in an entire country, focusing on the prestige of the journal where papers are published provides a good criterion for comparison.

The question which must now be addressed is that of how to select these «prestigious» journals that will serve as a basis for comparing the quality of mathematics research in different countries. We prepared a list of general mathematics journals by applying objective criteria (selecting the journals with the highest impact index from among those with an index of duration greater than ten years). We then added to this list a limited number of specialised journals in particular areas to ensure that these areas were represented. We

would like to stress that there may be other journals we have not included that have a level of quality similar to that of the thirty-five we have selected (some cut-off point was inevitable). We are confident that, statistically, the results of our study would not have changed much had we lengthened or shortened the list slightly.

The thirty-five journals (in alphabetical order) are the following:

- *Acta Mathematica*
- *Advances in Mathematics*
- *Annals of Mathematics*
- *Artificial Intelligence*
- *Biometrics*
- *Celestial Mechanics*
- *Commentarii Mathematici Helvetici*
- *Communications on Pure and Applied Mathematics*
- *Duke Mathematical Journal*
- *Econometrica*
- *Ergodic Theory and Dynamical Systems*
- *Inventiones Mathematicae*
- *Journal de Mathématiques Pures et Appliquées*
- *Journal für die Reine und Angewandte Mathematik*
- *Journal of Algebra*
- *Journal of Differential Equations*
- *Journal of Differential Geometry*
- *Journal of Functional Analysis*
- *Journal of Mathematical Analysis and Applications*
- *Journal of Mathematical Biology*
- *Journal of Number Theory*
- *Journal of the American Statistical Association*
- *Mathematics of Computation*
- *Mathematische Annalen*
- *Nonlinearity*
- *Probability Theory and Related Fields*
- *Proceedings of the London Mathematical Society*
- *Siam Journal on Numerical Analysis*
- *Siam Journal on Applied Mathematics*
- *Siam Journal on Control and Optimization*
- *Siam Journal on Discrete Mathematics*
- *Studies in Applied Mathematics*
- *The Annals of Probability*
- *The Annals of Statistics*
- *Topology*

Table 5. Comparison of countries (outstanding papers)

Country	1995 population	1995 GDP	Number of outstanding papers	Number of papers/population	GDP/population
Canada	29.6	586.6	1148	38.784	19.818
United States	263.2	7246	371	35.604	27.530
Switzerland	7.04	270.4	225	31.960	38.409
Denmark	5.23	158.7	152	29.063	30.344
France	58	1432.1	1562	26.931	24.691
Australia	18.1	336.3	450	24.862	18.580
Netherlands	15.45	361.6	355	22.977	23.405
Belgium	10.11	269.2	214	21.167	26.627
United Kingdom	58.3	1080.1	1217	20.875	18.527
Norway	4.36	136.3	91	20.872	31.261
Sweden	8.83	214	184	20.838	24.236
Germany	81.6	2207.8	1696	20.784	27.056
Austria	7.97	212.4	163	20.452	26.650
Catalonia	6.1	100.7	117	19.180	16.508
Finland	5.11	107.3	96	18.787	20.998
Iceland	0.27	7	4	14.815	25.926
Hungary	10.22	39.01	150	14.677	3.817
Italy	57.2	885	815	14.248	15.472
Ireland	3.58	60.1	47	13.128	16.788
Greece	10.45	102.3	117	11.196	9.789
Spain (excl. Catalonia)	33.1	430	364	10.997	12.991
Czech Republic	10.33	33.05	86	8.325	3.199
Bulgaria	8.77	10.26	73	8.324	1.170
Poland	38.6	94.6	317	8.212	2.451
Japan	125.1	4818.4	814	6.507	38.516
Portugal	10.8	103.2	55	5.093	9.556
Romania	22.68	27.92	94	4.145	1.231
Russia	147	392.5	248	1.687	2.670
Brazil	155.8	536.3	246	1.579	3.442
Argentina	34.59	275.66	42	1.214	7.969
Mexico	94.8	368.7	79	0.833	3.889
Ukraine	51.64	80.92	34	0.658	1.567
China	1221	630.2	771	0.631	0.516
Turkey	61.9	149	22	0.355	2.407
India	935.7	278.7	317	0.339	0.298

During the 1990-96 period, a total of 117 papers by authors associated with Catalan institutions were published in these journals. Bear in mind that the total number of papers published in Catalonia in this period is 1429. In other words, the papers published in the selected journals represent slightly more than 8% of total papers, and can therefore be qualified as *outstanding papers*.

A count was made of the number of papers published in these journals by authors of different countries. The results are shown in the Table 5.

Data for GDP and population are expressed in the same units as in Table 4, *Comparison of countries (total papers).* Given that, in our view, quality is a far more important factor to consider than quantity, a greater number of countries have been included here for comparison. The table is ordered according to the figures in the column «Number of papers/population». The country (of those in the table) that produces the most outstanding papers per person is Canada, and that which produces least is India. The United States, which in the table concerned with total papers was in the mid-area, now occupies the second position after Canada. As you will recall, Canada occupied the first position in Table 4, followed by Switzerland, which maintains a leading position in this comparison. In this table, Catalonia is situated in the upper half, ahead of many European countries (Finland, Iceland, Hungary, Italy, Ireland, Greece, rest of Spain, Czech Republic, Bulgaria, Poland, Portugal, Romania, Russia and Ukraine) and near the level of Sweden, Germany and the United Kingdom.

The results for Japan are surprising. Japan ranked poorly in terms of the number of papers published, and, in this measure of the excellence of the papers produced, it is once again to be found near the bottom of the table. In many areas of mathematics, however, there are outstanding Japanese researchers. Possibly, the explanation lies in the fact that Japan's population is twenty times greater than that of

Catalonia: though the level of mathematical activity may be far lower than expected, Japan still has far more researchers than Catalonia, and among these there are a small number who stand out for the excellence of their work.

Table 6 below shows the percentage of outstanding papers produced in various countries in relation to the total number of mathematics research papers published.

We will now examine a graph of the relationship between a country's GDP and its production of high-quality papers, taking the same approach applied in the case of total papers. In Figure 2, *Comparison of countries. Outstanding papers,* the horizontal axis indicates GDP/population, and the vertical axis number of outstanding papers divided by population.

Each country in the preceding table is represented by a point on the graph (indicated as a small square). Catalonia is represented by a square slightly larger than the others so that it may be easily distinguished. As in the previous graph, each country is easily identified: in Table 5 countries are ordered by number of papers/population which is the ordinate of the graph. For example, Canada is the first
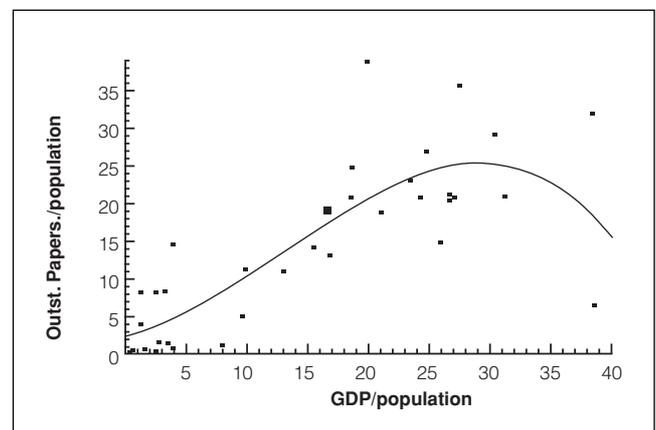
Figure 2. Comparison of countries. Outstanding papers.

Table 6. Comparison outstanding/total

Country	Number of outstanding papers	Total published papers	Percentage outstanding /total
United States	9371	90321	10.4
Norway	91	1074	8.5
Denmark	152	1811	8.4
Catalonia	117	1429	8.2
France	1562	20749	7.5
Canada	1148	15667	7.3
United Kingdom	1217	16664	7.3
Germany	1696	24165	7.0
Switzerland	225	3301	6.8
Sweden	184	2728	6.7
Austria	163	2544	6.4
Belgium	214	3634	5.9
Netherlands	355	6095	5.8
Spain (excl. Catalonia)	364	6408	5.7
Finland	96	1805	5.3
Italy	815	15717	5.2
Greece	117	2291	5.1
Portugal	55	1084	5.1
Japan	814	18366	4.4

country in the table, and is represented in the graph by the highest point.

It can be observed (as was the case when total publications were compared) that the form of the cloud of points is not linear. In this case, we have also approximated (by the minimum squares method) the cloud of points in the graph with a third degree polynomial, which is indicated by the curve drawn on the graph. As occurred in the comparison of total papers, as GDP increases so does the production of quality papers in mathematics; however, the rate of increase diminishes as GDP increases. The decrease in quality papers after a certain level of GDP is reached has no logical explanation: as in the case of Figure 1, the extreme position of Japan is the cause of this illogical downward turn of the curve.

Contrary to the results when «total papers published» was the criterion for comparison, when only outstanding papers are considered, Catalonia is positioned significantly above the curve. This implies that the quality of its mathematical production is higher than expected in relation to its GDP.

Many countries are represented in Figure 2 - 35 to be precise. Many of these have characteristics quite distinct from those of Catalonia (e.g. India, China, Mexico...). It is interesting to re-examine the same graph, but excluding countries that are not located in Europe. The countries that are left, in order of number of published papers per person are Switzerland, Denmark, France, the Netherlands, Belgium, the United Kingdom, Norway, Sweden, Germany, Austria, Catalonia, Finland, Iceland, Hungary, Italy, Ireland, Greece, Spain (excluding Catalonia), the Czech Republic, Bulgaria, Poland, Portugal, Romania, Russia and Ukraine. The resulting graph, when only these countries are considered, is shown in Figure 3.

In this case, the cloud of points has a linear form. The cloud of points has been approximated by a third degree polynomial as in the preceding graphs, and the result is close to a straight line. In other words, within our geographical area, the production of outstanding papers is a linear function of per capita GDP. Catalonia is once again above the curve in this graph, indicating that the quality of its math-
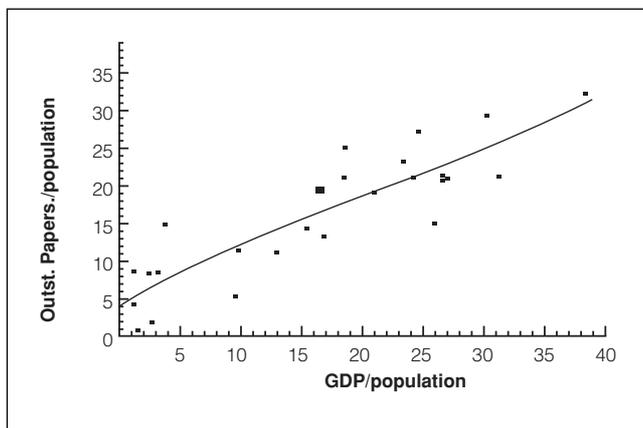

Figure 3. Comparison of countries. Outstanding papers.

ematical production is higher than expected in relation to its per capita GDP.

Evolution of outstanding mathematical production over the last ten years

In order to examine how the production of outstanding mathematics research papers in Catalonia has evolved over the last ten years, we made a count of the number of papers published in Catalonia in the thirty-five journals mentioned in the preceding section during the 1980-86 period. This figure was then compared with that for the 90-96 period. The computerized *Mathematical Reviews* database for the 80-86 period does not include information about the centre that the author of each paper is associated with. For the 80-86 period, therefore, we used the database of *Science Citation Index* for most of the thirty-five selected journals. For a few that are not covered by this index, a manual consultation was carried out. References to papers take longer to appear in *Mathematical Reviews* than in *Science Citation Index*. Given the change in the database used, the comparison is, in fact, being made between two periods more than ten years apart (possibly eleven or eleven and a half years). One of the thirty-five selected journals (*Nonlinearity*) did not exist during the 80-86 period. We therefore excluded data related to this journal from the 90-96 period, and proceeded to make the comparison on the basis of the thirty-four remaining publications.

In the 80-86 period, thirty-four papers by authors associated with Catalan centres were published in these journals, and 110 by authors associated with centres in the rest of Spain. In the 90-96 period, 112 papers were published in the same journals by authors associated with Catalan centres, and 363 by authors associated with centres in the rest of Spain. Over a period of ten years, Catalan production of outstanding papers increased by a factor of 3.3. The proportion of Catalonia's production of such papers in relation to that of the rest of Spain remained virtually unchanged over this period: in the course of this ten-year period, Catalonia did not advance more than the rest of Spain. It should be borne in mind, however, that during this period overall global production of mathematics papers increased by a factor of 1.34. If Catalonia had increased its production of outstanding papers by a factor of 1.34, this would not really have constituted any advance in relation to other countries. In fact, its production increased more than three fold.

Having now referred to the growth in the production of mathematics papers around the world over the last ten years, it is perhaps of interest to examine this growth over a longer period (though this represents a departure from the aim of our study). Table 7 (below) indicates the number of papers reviewed in the journal *Mathematical Reviews* in the years 1943, 1953, 1963, 1973, 1983 and 1993, and gives a long-term view of this trend:

From 1943 to 1953, production of papers increased by a factor of 2.55; from 1953 to 1963, by a factor of 1.96; from

Table 7. Evolution of mathematics production since 1943

Year	1943	1953	1963	1973	1983	1993
Number of papers	2834	7219	14147	29808	40195	54019

1963 to 1973, by a factor of 2.11; from 1973 to 1983, by a factor of 1.35; and from 1983 to 1993, by a factor of 1.34. All of these figures, as mentioned above, are based on reviews appearing in *Mathematical Reviews*. The major increases in the first ten-year periods may be the result of increases in the number of journals reviewed by *Mathematical Reviews*, or other factors such as World War II (the number of papers reviewed in 1943 is very low). It can be observed, however, that over the last 20 years there has been a sustained growth of 34% every ten years.

Funding

There are essentially three sources of subsidies for research groups in Catalonia: the Spanish Ministry of Education and Culture, the Autonomous Government of Catalonia and the European Union. Groups receiving these subsidies use them to cover expenses related to areas such as travel, attendance of congresses and meetings, invitation of researchers from abroad, and acquisition of reference and IT material. Of these subsidies, only those provided by the European Union can be used for remuneration of staff. Funding from the Spanish Ministry of Education and Culture reaches mathematics research groups through the DGICYT (the Directorate of Scientific and Technical Research) «Programme for the Promotion of Knowledge by Sectors». In the 90-96 period, this funding amounted to 201 million pesetas . During the same period CICYT (the Inter-Ministerial Committee on Science and Technology) provided 336 million pesetas for funding of projects with UNESCO codes corresponding to mathematics areas. The majority of these projects, however, involve engineering or computer science research groups working on matters that also involve mathematics (graphic computing, computer robotic vision, bioengineering). It would, therefore, be erroneous to include these resources in the quantification of mathematics research funding. In the 90-96 period, the Autonomous Government of Catalonia provided 35 million pesetas in research funding, specifically for projects subsidised by CIRIT (the Inter-Departmental Committee on Research and Technological Innovation). European Union project funding amounted to 130 million pesetas. Based on these figures, it can be concluded that 54.9% of funding for mathematics research groups came from the Ministry of Education and Culture, 35.5% from the European Union, and only 9.6% from the Autonomous Government of Catalonia. The ratio of the direct research group funding provided by the Autonomous Government of Catalonia to that provided by the Ministry of Education and Culture is 1 to 5.7. Clearly, Catalonia carries little weight in the administration of resources allocated for research. Many other autonomous regions of Spain also pro-

vide funding for research groups. The Basque region, for example, allocated 24 million pesetas in direct assistance for mathematics research groups in the 90-96 period, while Catalonia provided 35.2 million pesetas. On a per capita basis, Catalonia provided only half the resources that were dedicated to this area by the Autonomous Government of the Basque region.

In addition to direct funding of research groups, both the Ministry of Education and Culture and the Autonomous Government of Catalonia have provided significant financial resources in the form of indirect assistance. This includes training for researchers, subsidies for stays by visiting professors, assistance to improve infrastructure, etc.

For the 90-96 period, the total direct funding for Catalan research groups in mathematics (from DGICYT, CIRIT and European projects) was 366 million pesetas. This amount was allocated in the following manner to the different areas of mathematics as defined by UNESCO:

Logic	17.5	Numerical analysis	5.2
Algebra	35.9	Probability	17.3
Analysis and differential equations	85.2	Statistics and operative research	92.2
Computer science	32.2	Geometry and topology	35.6
Number theory	33.9	Other specialisations	11.3

Funding provided for mathematics libraries is another area to consider. There are currently three libraries of this type in Catalonia: the libraries of the faculties of mathematics at the University of Barcelona (UB) and the Polytechnic University of Catalonia (UPC), and the Department of Mathematics library at the Autonomous University of Barcelona (UAB).

The purchase of books and journals by the UB library constituted an investment of 128.4 million pesetas in the 90-96 period. For UAB, investment in this area amounted to 71.5 million pesetas, and for UPC, 20.2 million. These amounts are comparable to the direct funding for research groups discussed above, and, in a very high proportion, are provided by the universities themselves.

Publication of research papers

Five journals and a collection of books warrant mention for their regular publication in Catalonia of works in the mathematics field during the 1990-96 period. These publications focus largely on the work of authors from abroad: they publish few papers by Catalan mathematicians, who generally prefer to publish in journals based outside of Catalonia.

Journals

Collectanea Mathematica

First published in 1948, this is the Catalan mathematics research journal with the longest history. The journal is now published by the University of Barcelona (ISSN: 0010-757). Volumes 41, 42, 43, 44, 45, 46 and 47 were issued during the 1990-96 period. These contain a total of 162 research papers, four of which were written by authors associated with Catalan institutions, 35 by authors associated with institutions in the rest of Spain, and 123 by authors from the rest of the world.

Mathware & Soft Computing

This journal was created in 1994 and is published by the Mathematics and Computing Science Section of the Barcelona Higher Technical School of Architecture (ISSN: 1134-5632). The journal focuses on the use of mathematical tools and models that could be relevant in the cognitive sciences, pure or applied logic, and artificial intelligence. A volume of approximately three hundred pages, containing between twenty and thirty research papers, is published about once a year. Each volume consists of three issues.

Publicacions Matemàtiques

Published by the Autonomous University of Barcelona's Department of Mathematics, this journal was started in 1976 (ISSN: 0214-1493). Volumes 34, 35, 36, 37, 38, 39 and 40 were published in the 1990-96 period. These contain 272 research papers, 32 of them by authors associated with Catalan institutions, and 43 by authors associated with institutions in the rest of Spain. It should be noted that many of the papers by Catalan authors are contained in volume 36, which was dedicated to Pere Menal, a mathematician who worked at UAB, and who was killed in a traffic accident in 1991.

Qüestió

This journal, which ceased to be published in 1987, initiated a new stage in its existence when it reappeared in 1992. It is published by the Catalan Institute of Statistics with the support of the University of Barcelona, the Polytechnic University of Catalonia and the Catalan Institute of Statistics itself. Between 1992 and 1996, the journal published 84 papers, of which 26 were by authors associated with Catalan institutions.

Stochastica. Revista de Matemàtica Pura i Aplicada

The last issue of this journal appeared in 1992 (volume 13, ISSN:0210-7821). Before its disappearance, this journal produced one volume each year (made up of three issues), and was published by the Mathematics and Computing Science Section of the Higher Technical School of Architecture of Barcelona.

Book collections

Since 1993, the Ferran Sunyer i Balaguer Foundation, with the support of the Institute for Catalan Studies, has been awarding an annual prize in honour of the Catalan mathematician Ferran Sunyer i Balaguer. The prize supports the publication of an informative monograph dealing with the latest developments in an active area of mathematics research. Under an agreement with the publisher Birkhäuser, each year the winning monograph is published in a sub-collection of the collection «Progress and Mathematics». This sub-collection bears the coat of arms of the Institute of Catalan Studies on its cover, and includes a brief biography of Ferran Sunyer in its first pages. Since 1996, two books have been published in this sub-collection, corresponding to the first two editions of the prize (issues 125 and 128 of «Progress and Mathematics»).

Research centres

Centre for Mathematics Research

In 1984, the Institute for Catalan Studies created the Centre for Mathematics Research (Catalan acronim: CRM). The annual reports of this centre include the following description of its objectives: *to provide Catalan mathematicians with a research centre that will promote the development of mathematics research in Catalonia, both qualitatively and quantitatively. To achieve this objective, CRM invites distinguished scientists from around the world to spend time as visiting researchers in Catalan centres; provides young Catalan researchers with opportunities for contact with these visiting researchers and with scientific institutions; carries out research programmes; organises congresses, seminars and other scientific gatherings; and disseminates the results of research.*

CRM's research infrastructure is horizontally organised: it does not have its own research staff or directly sponsor any research group. It does sponsor postdoctoral fellowship holders and researchers from abroad, who, in most cases, are in contact with Catalan research groups. Similarly, many of the activities with which CRM is involved (congresses, seminars, courses, etc.) are jointly organised with Catalan research groups.

CRM is part of a European network that links it with similar groups such as the Newton Institute, the Mittag-Lefler Institute, the Max Planck Institute and others. It also participates in the Leibnitz programme, which provides postdoctoral fellowships in the mathematics field.

The Centre for Mathematics Research is located in the Faculty of Sciences building of the Autonomous University of Barcelona's Bellaterra Campus, under the terms of an agreement between the Institute for Catalan Studies and UAB.

CRM's infrastructure is a highly valuable complementary element in the development of mathematics research in Catalonia.

Table 8 outlines the centre's main activities, and shows how these evolved in the 1990-96 period.

In 1995, CRM became involved in a new area of activity - the regular organisation of courses dealing with advanced re-

Table 8. CRM activities in the 1990-96 period

	1990	1991	1992	1993	1994	1995	1996
Number of researchers	56	48	55	60	59	58	56
Number of conferences or seminars	104	106	135	180	230	169	178
Number of publications	23	21	45	57	36	39	31
Congresses organised	2	3	0	2	7	3	1

Table 9. Sources of funding (thousands of pesetas)

	1990	1991	1992	1993	1994	1995	1996
Carried forward and others	1,995	1,581	1,580	–	–	–	5,692
CIRIT	8,000	8,820	22,300	20,000	20,000	20,000	15,000
DGICYT	13,105	9,605	14,035	13,530	21,900	21,440	17,950
Institute for Catalan Studies	8,198	9,500		2,432	–		
OCSA		3,000					
CCHNA		0.3	0.2		–		
Intern. Coop.		0.56	0.24		–		
UAB			5,200	5,600	3,300	3,300	3,400
Autonomous Government (conv.)				12,815	17,276	7,420	5,775
EU				1,750	8,960	9,570	14,730
Totals	31,299	33,366	43,555	55,127	71,435	61,730	62,547

OCSA: Cultural Olympics, S.A.; CCHNA: Comité Conjunto Hispano Norteamericano.

search topics. The courses offered in 1995 were «Elliptic Co-homology» and «Complex Dynamics»; and in 1996, «Geometry and Physics», «Commutative Algebra» and «Homotopy Theory».

Table 9 shows the sources of funding for CRM. Funding from main sources (CIRIT and DGICYT) evolved favourably up until 1995 and then declined significantly in 1996. The recent and progressive benefit obtained from EU funds should also be noted.

Artificial Intelligence Research Institute

The Artificial Intelligence Research Institute (IIIA), based at the UAB campus since 1994, grew out of the Artificial Intelligence Research Group and is now part of the Scientific Research Council (CSIC).

In contrast to CRM, this institute does have its own personnel and includes a fairly homogenous research group distributed in two departments (intelligent systems and formal methods). Currently, the stable IIIA staff is made up of approximately fifteen researchers, mainly doctors in computing science with contractual ties to CSIC.

There is, without doubt, a strong mathematical component to the research done by this group. This is a clear example of the phenomenon referred to in the introduction to this article: the activity of this group is on the border between the field analysed in this report and other areas of research activity.

The research activity of this group essentially involves the production of publications, participation in projects and technology transfer. It should be noted that not all regular publications in the field of artificial intelligence are covered by *Mathematical Reviews*.

In the 90-96 period, IIIA received 110 million pesetas in funding from the European Union, and it is part of various European networks and networks of excellence.

Mathematics researchers are also trained at IIIA: there are fellowship holders, and doctoral theses are supervised. These fellowship holders and theses are not included in the tables because they are formally associated with computing science departments. At present, there are about ten fellowship holders. In the 90-96 period, nine these were read.

Other institutions related to mathematics

This section offers a brief description of the activity of other institutions related to mathematics research in Catalonia. Some contribute to this activity as research centres, and others are involved in promoting such research or disseminating its results.

One of the key institutions in the world of mathematics in Catalonia is the Catalan Mathematical Society, an affiliate society of the Institute of Catalan Studies. This society's objectives include the promotion of pure and applied research, as well as awareness raising and the dissemination of results. It is virtually the only link between mathematics at the universities and teaching staff at the secondary school level. Each year, in co-ordination with other countries, the society organises the Mathematics Olympiad and the Kangaroo Mathematics Competitions. These events are part of a highly effective campaign to promote mathematics at the pre-university level. The many public events (conferences, courses, etc.) held by the society contribute a great deal to the promotion of mathematics and the dissemination of knowledge in the field. As a member of the European Mathematical Society, the Catalan society was delegated the task of organis-

ing the European Mathematics Congress, that took place in Catalonia in the year 2000. Particularly noteworthy among its publications in the 90-96 period are a volume covering the work of the Catalan mathematician Pere Menal i Brufau (1994), the Catalan translation of *Disquisicions Aritmètiques* by C. F. Gauss (1996), and the regular publication of *Butlletí de la Societat Catalana de Matemàtiques.*

In 1996, the National Centre of Scientific Research in France, in conjunction with the Autonomous Government of Catalonia's Commission on Universities and Research, set up a «European Associated Laboratory» in the area of Intelligent Systems and Advanced Control (LEA SICA). The Associated Laboratory placed four existing groups under the same direction, and established a shared scientific programme. The four groups were the Symbolic Automatics Group (AS) of the LAAS of Tolosa, the Distributed Systems Automatics Group (ASD) of the IMP of Perpinyà, the Advanced Automatics Group (SAC) of the Polytechnic University of Catalonia (UPC), and the UPC's Knowledge Engineering Research Group (GREC). The GREC is an applied mathematics group created by Professor Núria Piera Carreté (who sadly was killed while this report was being prepared). At the time that LEA SICA was founded, GREC was made up of five researchers. Funding of this laboratory is provided primarily by the CNRS of UPC.

Also worth mentioning is the Catalan Institute of Statistics, which was created in 1989 and is under the authority of Autonomous Government of Catalonia's Department of the Economy and Finances. One of the institute's objectives is to promote research in statistics and the development of this field in the various subject areas in which the institute is involved.

Conclusions

– The state of mathematics research in Catalonia is similar to that in other advanced countries. In terms of the number of outstanding papers published, Catalonia is practically on a par with countries traditionally regarded as highly advanced, such as Germany, the United Kingdom, Sweden and Austria. Catalonia is ahead of Italy - a country with a long tradition in the mathematics field - though still far from the level of France, Switzerland, Canada and the United States.

– In the last ten years, Catalonia has increased the number of outstanding papers published by a factor of 3.3. The number of papers published for the rest of Spain has increased by the same factor. The impressive development that has taken place here has been uniform throughout the state.

– Very few Catalan mathematicians are members of the editorial boards of prestigious research journals. This lack of representation is not consistent with the quantity and quality of research done in Catalonia. Catalan mathematicians are also significantly underrepresented in the international bodies responsible for the design of scientific policy. This may be due to the lack of a long mathematics tradition in

Catalonia (only for a relatively short time has a significant amount of activity in this field been going on). Initiatives should be undertaken to increase Catalan influence in international forums.

– Of the direct funding provided for research groups by the Ministry of Education and Culture, the Autonomous Government of Catalonia and the European Union, only 9.6% comes from the Autonomous Government. The ratio of funding provided by the Autonomous Government to that provided by the Ministry of Education and Culture is 1:5.7. Clearly, Catalonia currently carries little weight in the administration of resources allocated to research. Bearing in mind that all of the autonomous regions allocate funds for mathematics research and that the university structure is the same throughout the state, it is not surprising that the development of research activity has been uniform throughout Spain over the last ten years.

– Direct assistance for research groups provided by the Ministry of Education and Culture is, for the most part, channelled through the DGICYT «Programme for the Promotion of Knowledge by Sectors». Within the limits marked by a general scarcity of resources, funding policy over the years has been based on a consistent set of principles: assistance has been provided to Catalan researchers in a manner that accurately reflects the quality of their production.

– University library policy should be clearly co-ordinated, and based on adequate economic resources.

– Data concerning the economic resources allocated to mathematics research in recent years lead us to conclude that this research has been carried out at a very low cost. The level of research funding has been very limited, despite the fact that basic research of this type is fundamental to the technological development of a country.

– In the 90-95 period, the stable teaching staff at Catalan universities for the mathematics area grew by a factor of 1.81. UAB experienced the lowest level of growth in stable teaching staff (just a 1.2-fold increase).

– UAB also has the lowest proportion of stable teaching staff in relation to total teaching staff.

– The number of fellowship holders is low at all of the universities, and particularly at UPC. An effective policy of incentives for research would involve a significant increase in the number of fellowship holders, an increase in the amount of fellowships, creation of a sufficient number of positions for assistant instructors, and the disappearance of «false» adjunct instructors (instructors hired as adjuncts who in fact have all the characteristics of assistant instructors).

– Strong incentives should be provided for any initiatives intended to apply theoretical mathematics research to specific problems that arise in other sciences, engineering or economics, even if these applications do not lead immediately to the production of research papers.

– Among professors at Catalan universities, there are still potential researchers who have not participated in research projects that are regarded as competitive.

– In general, the areas of mathematics specialisation that

have the highest number of global publications (the most productive) are well represented in Catalonia, with the exception, perhaps, of partial differential equations and numerical analysis, areas in which few Catalan researchers are working. These areas of specialisations should, therefore, be promoted.

– It would be highly beneficial to try to attract papers of unquestionable quality for publication in Catalan journals. In this manner, the level of international regard for these journals (already well-considered) could gradually be raised. Catalonia now has the research potential necessary to publish a high-quality research journal.

– A number of institutions have emerged that have played an important role in the development and promotion of research activity. Strengthening these institutions would help encourage these activities in the future.

APPENDIX B

Mathematics in Catalonia: 1996-2002

forum

Mathematics in Catalonia: 1996-2002*

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1. Introduction

The aim of this article is to present the main conclusions of the report on research in Catalonia for the area of mathematics. The report was published in 2005 by the Institute for Catalan Studies.

This is a report of the scientific activity in Catalonia in the field of mathematics during the period 1996-2002. It deals with two aspects of mathematics research. First, it provides an analysis of the country's research potential, as defined by its universities and other centers of investigation, their staff, as well as the economic resources that they obtain for research. Second, it offers an assessment of the scientific productivity of researchers from these institutions, as measured by analyzing, both quantitatively and qualitatively, articles published in specialized mathematics journals and doctoral theses submitted to universities.

The data from our study are often compared with those from the report on research in mathematics corresponding to the period 1990-1996. A summary of that information and the conclusions drawn from that earlier report can be found in the article by Joan Girbau "Mathematics in Catalonia" [*Contributions to Science, 2(1):111-121 (2001)*].

2. Universities and their human resources

In Catalonia, research in mathematics is mostly carried out at universities. In this section, we provide quantitative information about the mathematicians working at these institutions. However, only mathematicians working in the Mathematics departments have been considered; thus, mathematicians that carry out their research in other departments, such as Economics and Computer Science, are not included in this study. However, their productivity is discussed in the data reported in the section "Scientific productivity".

Table 1 presents the figures concerning the staff at catalan universities. The data correspond to the academic year 2001-2002, which is the last year of the period analyzed.

During the period 1996-2002, there was an increase of 15% in the number of teaching and research staff employed in the Mathematics departments of Catalan universities. This total increase, which was not uniform for all categories, shows that there has not been stagnation during this period; rather, the number of fellowship holders at the University of Barcelona, the Autonomous University of Barcelona, and the Technical University of Catalonia has increased significantly.

Table 1. Permanent teaching staff, term-contract teaching staff, and fellowship holders.

University	Permanent teaching staff	Term-contract teaching staff	Fellowship holders	Total
Autonomous University of Barcelona	55	48	10	113
University of Barcelona	79	30	15	124
University of Girona	14	9	2	25
University of Lleida	17	10	–	27
Polytechnical University of Catalonia	193	79	22	294
University Pompeu Fabra	16	8	–	24
University Rovira Virgili	14	–	3	17
Total	388	184	52	624

3. Scientific productivity

3.1. Doctoral theses

Table 2 shows the number of doctoral theses on mathematics submitted to Catalan universities between the academic yar 1995-96 and the academic year 2001-02. There was a remarkable increase (ca. 37%) in the number of theses submitted during the more recent period compared to the period 1990-1996. The increase in the number of fellowship holders (158%) during this time most likely accounted for the increase in the number of theses.

Despite this increase, the rate of theses supervised by permanent teaching staff was 0.45, which is markedly lower than during the period 1990-1996, indicating a decrease in productivity in relation to the potential of Catalan universities.

Table 2. Doctoral theses submitted to each university during the period 1995-2002.

University	Doctoral theses submitted
Autonomous University of Barcelona	32
University of Barcelona	46
University of Girona	1
University of Lleida	0
Polytechnical University of Catalonia	78
University Pompeu Fabra	5
University Rovira Virgili	0
Total	162

3.2. Scientific publications

Scientific productivity in the field of mathematics in Catalonia during the period 1996-2002 is analyzed from two points of view. First, the evolution of productivity of Catalan mathe-

matics is compared with that worldwide; Second, productivity in Catalonia is compared with that of countries having the highest productivity in mathematics. Catalan productivity is compared with worldwide productivity, first of all, by taking into account, for each year of the period analyzed (Table 3), all papers published in mathematics. After that the data are evaluated following the UNESCO codes (Table 4) for the classification of subfields in mathematics. All the studies carried out include only work that was reviewed in the journal *Mathematical Reviews* during the period 1996-2002 and which have been published in journals, congress proceedings, or books. Note that, after a manuscript is sent for publication, it takes an average of 2-3 years for it to be listed in *Mathematical Reviews*. The papers that enter in the account of catalan productivity are those having at least one author from a Catalan institution.

Table 4 shows the distribution of papers published around the world and in Catalonia, in accordance with the UNESCO codes. The differences that can be seen between the totals in Table 3 and those in Table 4, both in Catalonia and around the world, are due to the fact that many articles in *Mathematical Reviews* correspond to what could be called border fields in mathematics, such as physics and economics, and thus have UNESCO codes different from those we have considered.

The total number of publications during the period 1996-2002 in Catalonia is 2584, compared to 472633 worldwide. Catalan productivity in mathematics represents 0.5% of global production, a percentage higher than during the previous period (0.4%). In addition, compared with the period 1990-1996, the number of publications in the world has increased by a factor of 1.28, while in Catalonia it has increased by a factor of 1.71.

Table 3. Total number of mathematics publications in Catalonia and around the world.

1996	1997	1998	1999	2000	2001	2002	1996-2002
Catalonia							
293	321	397	395	384	383	411	2584
World							
63064	66590	67886	70025	70217	69170	65681	472633

Table 4. Partial distribution of mathematics publications around the world and in Catalonia according to UNESCO codes.

Area and UNESCO code	World	%	Catalonia	%
Logic (1101-1104)	11627	3.16	132	6.45
Algebra (1201)	34374	9.34	149	7.28
Analysis (1202)	92179	25.05	501	24.46
Computer Science (1203)	23344	6.35	225	10.99
Geometry (1204)	32285	8.78	176	8.59
Number Theory (1205)	14505	3.94	58	2.83
Numerical Analysis (1206)	22228	6.04	50	2.44
Operative Research (1207)	6560	1.78	12	0.59
Probabilities (1208)	16702	4.54	125	6.10
Statistics (1209)	23100	6.28	87	4.25
Topology (1210)	15553	4.23	65	3.17
Total	292457	100.0	1580	100.0

Analysis of the distribution according to classification of the works in the different fields, as defined by the UNESCO codes, shows that the relative volume of Catalan production is comparable to that worldwide in all eleven areas considered, except Logic, Numerical Analysis, and Operative Research. In the category Logic, the percentage of Catalan productivity is almost twice as high as the global one, while in Numerical Analysis and Operative Research it is less than half of total global production.

Productivity in mathematics in Catalonia was compared with that in countries having the highest levels of productivity, defined as those countries with more than 2000 publications reviewed in *Mathematical Reviews* during period 1996-2002. The list of Table 5 comprises 33 countries, almost all of them considered in the 1990-96 study. Most of the countries with a high degree of development appears in this list.

In table 5, the 2002 population is given in millions of persons and the 2002 GDP in dollars per inhabitant. "Publications" is the sum of articles, proceedings and books. The data from the 33 countries ae sorted according to the figures for the column "Number of publications by million inhabitants ", i.e., from the highest to the lowest. An analysis of these figures (and those corresponding to the previous period) shows that mathematical production in Catalonia in 1996-2002 relative to population increased compared to the period 1990-1996 by a factor of 1.66.

Note that Israel ranks first, far ahead of the other countries, while other mathematically productive countries, such as Japan or Russia, occupy lower positions. Catalonia ranks 15, which is the same position that it occupied during the previous period, and it has surpassed other countries, including the United States, Germany, the United Kingdom, and Italy.

The relationship between GDP and publications by million inhabitants is heterogeneous. For some countries this relation tends to be linear. However, in the majority of countries, the number of articles per million inhabitants is higher than would be expected if the relationship was directly proportional.

3.3. Analysis of the quality of publications

In the previous section, we considered all articles on mathematics published in Catalonia and worldwide, taking into account only the quantity, not the quality of these articles. We now turn our attention to the quality of the work produced. One indicator of the quality of a scientific article is its citation index, which is based on the number of citations by other authors over a given period of time. However, in our opinion, this index, which may be adequated for many scientific disciplines, should not be so good for mathematics. We believe that there is no direct rela-

Table 5. List of countries arranged by total mathematics papers/population rate.

	Country	2002 Population	2002 GDP	Art.	Publications	Publications/population
1	Israel	6	16710	6828	8344	1284.83
2	Switzerland	7	38930	3425	4298	594.67
3	Canada	31	22300	13627	16324	519.64
4	France	59	22010	23779	29878	502.64
5	Singapore	4	20690	1863	2072	497.60
6	Finland	5	23510	2004	2516	483.94
7	Denmark	5	30290	2003	2572	478.67
8	Belgium	10	23250	3985	4823	467.34
9	Austria	8	23390	2866	3716	456.46
10	Sweden	9	24820	3246	4024	450.92
11	The Netherlands	16	23960	5555	7164	443.76
12	Australia	20	19740	7337	8590	438.69
13	Czech Republic	10	5560	3404	4224	413.72
14	Hungary	10	5280	3573	4153	408.52
15	Catalonia	6	20458	2057	2525	388.10
16	Germany	82	22570	24290	31969	387.53
17	United Kingdom	59	25250	18668	22715	385.93
18	Italy	58	18960	18365	21920	378.46
19	USA	288	35060	79824	97432	337.87
20	Spain[a]	34	16475	9195	11158	327.79
21	Bulgaria	8	1790	2072	2511	319.14
22	Greece	11	11660	2864	3138	295.18
23	Poland	39	4570	8810	10299	266.63
24	Rumania	22	1850	5238	5943	265.85
25	Japan	127	33550	22902	26251	206.47
26	Russia	144	2140	22211	25764	178.83
27	Ukraine	49	770	6697	7632	156.66
28	Korea	48	9930	6189	6555	137.59
29	Brazil	174	2850	4923	5482	35.50
30	China	1281	940	43087	44839	35.00
31	Turkey	70	2500	2202	2348	33.54
32	Mexico	101	5910	2283	2873	28.44
33	India	1048	480	9406	10400	9.92

a. Without Catalonia.

tionship between the quality and significance that an article may have for the development of mathematics and its low term citation frequency. Thus, we have chosen to use an indirect measure of the quality of an article: the level of prestige of the journal in which it is published. Needless to say, any approach to measuring a journal's prestige can be objectionable, but our aim is to obtain data that allow comparisons with other countries to be established, rather simply reflecting the level of excellence of Catalan productivity in any field, and using as many approaches as possible.

We have defined "prestigious journals" as those with the highest impact factor among those with an index of persistence greater than 10 years. We then added to this group a limited number of specialized journals in particular areas to ensure that all areas were represented. The total number of articles published worldwide in the journals listed below (referred to as outstanding articles), over the period 1996-2002, amounts to 6.16% of the total number of articles published in all journals reviewed in *Mathematical Reviews* over the same period.

List of prestigious journals:

- *Acta Mathematica*
- *Advances in Applied Probability*
- *Advances in Mathematics*
- *American Journal of Mathematics*
- *Annals de l'Institut Fourier*
- *Annals of Mathematics*
- *Annales Scientifiques de l'École Normale Supérieur*
- *Archive for Rational Mechanics and Analysis*
- *Arkiv för Mathematik*
- *Artificial Intelligence*
- *Biometrika*
- *Bulletin of the American Mathematical Society*
- *Celestial Mechanics and Dynamical Astronomy*
- *Combinatorica*
- *Commentari Mathematici Helvetici*
- *Communications on Pure and Applied Mathematics*
- *Duke Mathematical Journal*
- *Econometrica*
- *Ergodic Theory and Dynamical Systems*
- *Indiana University Mathematical Journal*
- *Inventiones Mathematicae*
- *Journal d'Analyse Mathématique*
- *Journal de Mathématiques Pures et Appliquées*
- *Journal für die Reine und Angewandte Mathematik*
- *Journal of Algebra*
- *Journal of Differential Equations*
- *Journal of Differential Geometry*
- *Journal of Functional Analysis*
- *Journal of Mathematical Analysis and Applications*
- *Journal of Mathematical Biology*
- *Journal of Number Theory*
- *Journal of the American Mathematical Society*
- *Journal of the American Statistical Association*
- *Journal of the Royal Statistic Society*
- *Mathematics of Computation*

- *Mathematische Annalen*
- *Mathematische Zeitschrift*
- *Nonlinearity*
- *Proceedings of the London Mathematical Society*
- *SIAM Journal on Applied Mathematics*
- *SIAM Journal on Control and Optimization*
- *SIAM Journal on Discrete Mathematics*
- *SIAM Journal on Numerical Analysis*
- *Studies in Applied Mathematics*
- *The Annals of Probability*
- *The Annals of Statistics*
- *Topology*
- *Transactions of the American Mathematical Society*

On this basis, we have counted the number of outstanding articles published in any of the journals listed above by authors in the 33 countries listed in Table 5. The results are shown in Table 6, in which the countries have been sorted according to the ratio of number of outstanding articles by million inhabitants. In Table 7 the countries are sorted according to the percentage of articles published in the above list of prestigious journals compared with the total number of articles published.

Table 6. List of countries by number of outstanding articles/million inhabitants.

	Country	Population	Outstanding articles	Outstanding articles /population
1	Israel	6.5	854	131.38
2	France	59.4	3179	53.52
3	Switzerland	7.2	352	48.89
4	Canada	31.4	1351	43.03
5	Denmark	5.4	222	41.11
6	Catalonia	6.5	254	39.08
7	Sweden	8.9	343	38.54
8	USA	288.4	11020	38.21
9	Australia	19.6	679	34.64
10	United Kingdom	58.9	2004	34.02
11	Finland	5.2	167	32.12
12	Singapore	4.2	133	31.67
13	Germany	82.5	2584	31.32
14	Belgium	10.3	297	28.83
15	The Netherlands	16.1	456	28.32
16	Austria	8.1	225	27.78
17	Spain[a]	34.0	915	26.91
18	Italy	57.9	1377	23.78
19	Hungary	10.2	213	20.88
20	Greece	10.6	215	20.28
21	Czech R.	10.2	172	16.86
22	Poland	38.6	440	11.40
23	Japan	127.1	1396	10.98
24	Bulgaria	7.9	80	10.13
25	Rumania	22.4	169	7.54
26	Korea	47.6	328	6.89
27	Russia	144.1	489	3.39
28	Brazil	174.5	448	2.57
29	Ukraine	48.7	123	2.53
30	Mexico	100.9	135	1.34
31	China	1281.0	1613	1.26
32	Turkey	69.6	64	0.92
33	India	1048.3	361	0.34

Table 7. List of countries ordered by outstanding articles/total articles (%).

	Country	Outstanding articles/total articles		Country	Outstanding articles/total articles
1	USA	13.80	18	Italy	7.50
2	France	13.37	19	Belgium	7.45
3	Israel	12.50	20	Singapore	7.14
4	Catalonia	12.34	21	Japan	6.10
5	Denmark	11.08	22	Hungary	5.96
6	United Kingdom	10.73	23	Mexico	5.91
7	Germany	10.63	24	Korea	5.30
8	Sweden	10.57	25	Czech Republic	5.05
9	Switzerland	10.27	26	Poland	5.00
10	Spain*	9.95	27	Bulgaria	3.86
11	Canada	9.91	28	India	3.84
12	Australia	9.25	29	China	3.74
13	Brazil	9.10	30	Rumania	3.23
14	Finland	8.33	31	Turkey	2.91
15	The Netherlands	8.20	32	Russia	2.20
16	Austria	7.85	33	Ukraine	1.84
17	Greece	7.78			

a. Without Catalonia.

An analysis of the figures provided shows that 254 articles were published by Catalonia in prestigious journals during the period 1996-2002, indicating a 1.59-fold increase compared to the previous period. In the rest of the world, there was a 1.16-fold increase.

For Catalonia, the ratio "Number of outstanding articles by million inhabitants "(Table 6) increased from 19.18 (1990-1996) to 39.04 (1996-2002), thus moving from 14th to 6th place on the list. Note that this ratio may be influenced by the fact that the list of prestigious journals used in this study comprises a few more journals than the list used in the previous study (1990-1996). Catalonia has surpassed some European countries, including Germany, Sweden and the United Kingdom, which, like Catalonia, have not had large population changes. So, the rate of increase of outstanding articles in Catalonia was higher than in those three other countries.

From the data shown in Table 7, it can be seen that Catalonia ranks quite high in the list, in fourth place. The only surrounding European country that is ahead of Catalonia is France. For Catalonia, the ratio "Outstanding articles/total articles" increased by a factor of 1.22 compared to the previous period.

3.4. Analysis of the degree of collaboration in scientific publications

When analyzing the state of the art of mathematics research in Catalonia, we felt it was important to also consider both the number of articles written in collaboration with mathematicians from outside Catalonia and with which countries this kind of collaboration most frequently occurred. The results of this type of analysis may be interpreted in several ways. Some readers may think that collaborating with foreign colleagues means that the capabilities of Catalonian mathematicians are limited and help is needed from outside sources. Alternatively, a high collaboration index can be viewed as corresponding to a high level of mathematical capabilities, which allows interactions in various mathematics-related subjects and with different research groups from around the world. Regardless of the interpretation and subsequent conclusion, analysis of the degree of collaboration provides further insight into the state of mathematics research in Catalonia.

Table 8 lists the 15 countries that collaborated most frequently with Catalonia in publishing mathematics articles. The data reflect the degree of collaboration between the countries in absolute numbers. Most of the collaborations were with mathematicians in

Table 8. Number of articles written in collaboration

	USA	Spain	France	UK	Italy	Germany	Canada	The Netherlands	Mexico	Argentina	Japan	China	Russia	Belgium	Catalonia
USA		692	2281	2507	1642	2812	2739	846	235	148	1039	1773	893	470	221
Spain	692		337	260	282	211	116	101	96	93	39	77	150	216	214
France	2281	337		532	916	884	496	200	89	49	269	167	606	256	136
UK	2507	260	532		490	810	480	261	61	20	213	339	365	161	87
Italy	1642	282	916	490		677	290	185	34	43	169	120	512	146	70
Germany	2812	211	884	810	677		499	401	97	25	350	408	984	183	67
Canada	2739	116	496	480	290	499		169	51	16	228	601	204	80	47
The Netherlands	846	101	200	261	185	401	169		5	7	84	78	116	143	33
Mexico	235	96	89	61	34	97	51	5		5	72	14	106	9	33
Argentina	148	93	49	20	43	25	16	7	5		3	1	1	9	33
Japan	1039	39	269	213	169	350	228	84	72	3		371	193	47	30
China	1773	77	167	339	120	408	601	78	14	1	371		64	54	27
Russia	893	150	606	365	512	984	204	116	106	1	193	64		62	27
Belgium	470	216	256	161	146	183	80	143	9	9	47	54	62		21
Catalonia	221	214	136	87	70	67	47	33	33	33	30	27	27	21	

Table 9. Funding

	1996	1997	1998	1999	2000	2001	2002	Total
Catalan Government Projects Spanish Ministry Education	223,641	330,166	476,607	394,258	596,485	890,247	561,403	3,472,808
and Culture	493,974	607,851	377,927	614,377	801,832	952,552	1,366,702	5,215,215
European Union	851,495	419,661	385,726	342,062	589,333	529,365	823,216	3,940,858

the United States, Canada, and European countries close to Catalonia. Nonetheless, Catalan mathematicians collaborated more often with colleagues in Mexico, Argentina, Japan or China than with those in countries such as Belgium or Scandinavia.

4. Funding and infrastructure

In analyzing the sources that fund mathematics research, the cost of maintaining infrastructure, including buildings, libraries, computer equipment, and lecture rooms, should be taken into account. There are also personnel costs, that is, the salaries of everyone working in mathematics research at any institution in Catalonia. Besides this direct grants for research, which fund many research groups, finance research projects, the organization of congresses, fellowships for visiting foreign researchers, scholarships for training researchers, etc. In the following, we refer mostly to direct grants for research and less frequently to bibliographic support and computer equipment.

There are essentially three sources of subsidies for Catalonian mathematics research: the Catalan Government, the Spanish Government, and the European Union. Table 9 summarizes the funding by theses three sources during the period 1996-2002.

The Catalan Government has established several diverse programs to fund research groups, projects, and individual researchers. Among these programs, the one set up to fund "consolidated research groups" in Catalonia stands out since it aims to strengthen research groups by requiring that projects be cofunded by the group. At the end of the period 1996-2002, there were 18 consolidated groups in mathematics in Catalonia, comprising 263 researchers from Catalan universities, a number that represents 60% of the potential mathematics researchers in Catalonia. These groups received a total amount of 1,089,567 Euros during that time.

The programme of the Spanish Government that much provides funding for mathematics research is the "Sectorial programme to promote general knowlege". While a few Spanish programs fund research in areas that we considered to be related, they have little impact on funding in the field of mathematics itself. Only a few of these programs, such as the "*Telematic Services and Applications*" and Space Research, finance work in mathematics, and most of the funding is indirect.

Even though mathematics is not a priority for the European Union, there are several programs that support research. These have been funded by the European Union with the goal of creating thematic networks that facilitate researcher mobility and aid in the organization of courses and congresses.

In Catalonia, during the period 1996-2002, research pro-

jects centered around mathematics received more than 10 million Euros. Regarding the sources of funding, only 13.8% came from the Catalan Government. The main source of funding is the Spanish Government, with 49.5%, followed by the European Union with 36.7%. Comparing these figures with those from the period 1990-1996, there was an increase of 4% in the funds from the Catalan Government, and a decrease of 5% in the funding received from Spanish Government, while the European Union's funding remained at the same level.

Funding provided for mathematics libraries is another area of consideration. The investment three libraries of this type in Catalonia: at the faculties of Mathematics at the University of Barcelona (UB) and the Technical University of Catalonia (UPC), and at the Department of Mathematics at the Autonomous University of Barcelona (UAB). The investment in books and journals at the mathematics library of the University of Barcelona during the period 1996-2002 amounted to 1,213,700 Euros. At the Department of Mathematics at the University Autonomous of Barcelona, 498,942 Euros were invested, while at the Statistics and Mathematics Faculty of the Polytechnical University of Catalonia this investment was 286,244 Euros.

Comparing these figures with those from the previous period, investments in books and journals at Catalan universities from 1996 to 2002 markedly increased. Nonetheless, both at the University of Barcelona and the University Autonomous of Barcelona, the number of journal subscriptions decreased. The Polytechnic University of Catalonia doubled its outlay for books and started investing in journals. The total investment in Catalonia in bibliographic material related to mathematics during the period 1996-2002 was almost 2 million Euros, an increase of more than 40% compared with the previous period. This amount was less than 20% of the total direct financial help received by research groups.

Together with books and journals, computer resources are among the most important forms of support required by researchers in mathematics. Without entering into a lengthy description of the types of computer equipment found in Catalan universities and other research centers, the equipment of the Dynamics Systems Group of the UB and UPC, which includes a HIDRA parallel computer (Beowulf computer) that provides service to a large number of users, should nonetheless be mentioned.

5. Other centers and institutions involved in mathematics research

As noted above, mathematics research in Catalonia is carried out essentially at universities, but there are other research centers that either do research in mathematics or are involved in

mathematics-related collaborations in Catalonia. In this section, we will briefly describe these centers and institutions.

Center for Mathematics Research (CRM).

The CRM is a consortium between the Catalan Government and the Institute for Catalan Studies that invites distinguished mathematicians from around the world to spend time as visiting researchers. It sponsors research programs and organizes thematic semesters, congresses, and seminars. The activities of the CRM are carried out in coordination with research groups from Catalan universities.

Mathematics Institute of the University of Barcelona (IMUB).

The IMUB is a research center linked to the University of Barcelona that is dedicated to research and basic training in all the fields of pure and applied mathematics. It develops-and supports-research in mathematics, including the organization of scientific activities such as advanced courses, workshops, conferences, and seminars.

Institute of Research on Artificial Intelligence (IIIA).

The IIIA is a center of the Spanish Scientific Research Council, located at the campus of the University Autonomous of Barcelona. Some of its scientific activity is directly devoted to mathematics but it is also involved with Information Technology, which also has an important mathematical component.

Catalan Society of Mathematics (SCM).

The SCM is a subsidiary of the Institute of Catalan Studies that promotes both theoretical and applied research in mathematics. It acts as a meeting point between mathematicians from the various Catalan universities and those working as mathematics teachers in high schools.

Institute of Spatial Studies of Catalonia (IEEC).

The IEEC is a private foundation that promotes activities, studies, and projects related to scientific research and space technology.

Statistics Institute of Catalonia (IDESCAT).

IDESCAT belongs to the Ministry of Economics and Finance of the Autonomous Government of Catalonia. Its objective is to promote research and development in the field of statistics.

Ferran Sunyer i Balaguer Foundation.

This is a private foundation, sponsored by the Institute for Catalan Studies, that grants an annual award bearing the name of the Catalan mathematician Ferran Sunyer i Balaguer. The award is given to a monograph on recent developments in any field of mathematics.

6. Edition of Scientific publications

One of Catalonia's contributions to the development of mathematics is the publication of several periodical journals of mathematics. For the period 1996-2002, these publications included:

Collectanea Mathematica.

This is the oldest Catalonian mathematics journal. Its publication, by the University of Barcelona, began in 1948. The journal is exchanged by the University of Barcelona Mathematical Library with several international journals.

Publicacions matemàtiques.

Published by the Department of Mathematics of the Autonomous University of Barcelona. Its publication began in 1976 and it has been in the ISI databases since 2002. It is published by IDESCAT, sponsored by the University of Barcelona and the Polytechnical University of Catalonia. Since 2003 its name is "Statistics and operations research".

Mathware & Soft Computing.

This journal was created in 1994 and is published by the Mathematics and Computing Section of the School of Architecture of Barcelona, which publishes works in the fields of cognitive science and artificial intelligence.

Butlletí de la Societat Catalana de Matemàtiques.

This journal publishes, in Catalan, articles in any field of mathematics, that may be of interest to a large number of readers.

Qualitative Theory of Dynamical Systems.

The University of Lleida has published this journal since 2000. It consists of articles concerning the theory, methods, and applications of dynamic systems.

Book collections.

The CRM, by means of an agreement with the Birkhäuser publishing house, produces a collection of books based on the contents of the Advanced Courses organized by the CRM.

Publications of the CIMNE.

The International Center of Numerical Methods in Engineering, which is a consortium between the Catalan Government and the Polytechnical University of Catalonia, publishes "Archives of Computational Methods in Engineering" and "Revista Internacional de Métodos Numéricos para cálculo y diseño en ingeniería".

7. Conclusions

1. Among the Universities with mathematics programmes, prmanent teaching satff increased only at the Autonomous University of Barcelona, wich previously had the lowest rate of permanent teaching staff.

2. The number of permanent teaching staff has stabilized. While this can have a positive effect on research dynamics, there is also a negative effect on the incorporation of young researchers. New professional paths for mathematicians through connections between university and the industrial and business worlds should be developed.

3. The number of fellowship holders at the three universities with mathematics programs significantly increased com-

pared with the previous period. This probabily resulted in an increase in the number of doctoral theses in Catalonia. The number of doctoral theses submitted by visiting students also increased. However, the total number of theses submitted was low when compared with the scientific potential of Catalan universities.

4. An analysis of mathematical productivity according to country showed that, in Mathematics research, Catalonia maintained or improved its position among the most advanced countries. It should be noted, however, that the most rapid increase in productivity occurred up until the mid-1990s. The numbers seem to point out that a steady state was subsequently reached and that mathematics research in Catalonia has now entered a period of maturity.

5. The most productive fields in mathematics around the world are also highly productive in Catalonia, except for Numerical Analysis and Partial Differential Equations, which need to be strongly promoted in the future.

6. The number of outstanding publications in relation to the size of the population in Catalonia and the country's position compared with surrounding European countries increased over the previous period.

7. Catalonian mathematicians frequently collaborated with mathematicians from other countries. More than 40% of the mathematics publications in Catalonia included authors from other countries, especially from the United States and surrounding European countries.

8. Catalonia should have more weight in the administration of resources dedicated to research. In the line to assisting research groups according to the quality of their productivity, the resources available for mathematics research should be increased, thereby promoting both scientific and technologic development. Catalonia has the appropriate conditions for making a qualitatively important advance in Mathematical research, provided that it receives the necessary financial support.

9. Although investments in mathematics libraries at Catalan universities increased in absolute numbers, but amount devoted to journals subscriptions remains insufficient due to large increases in subscription costs.

10. Despite the high level of mathematics research in Catalonia, its international recognition remains low. This may be probably due to the lack of a mathematical tradition. It is necessary to increase the presence of Catalan mathematicians on the committees of outstanding journals and in the decision-making groups of international institutions that formulate scientific policies. A major step to raise the prestige of Catalan mathematics would most certainly be to increase the quality of Catalan mathematics journals to the level of outstanding journals.