Some Challenges in Operations Research

Marco A. López Cerdá

January 21, 2010

1. What is Operations Research?

According to the Institute for Operations Research and the Management Sciences (**INFORMS**):

"**Operations Research or Operational Research** (**OR**) is an interdisciplinary branch of mathematics which uses methods like mathematical modeling, statistics, and algorithms to arrive at optimal or good decisions in complex problems which are concerned with approaching the maxima (profit, faster assembly line, greater crop yield, higher bandwidth, etc.) or the minima (cost loss, lowering of risk, etc.) of some objective function. The eventual intention behind using Operations Research is to elicit a best possible solution to a problem mathematically, which improves or optimizes the performance of the system."

We can adopt the following simplifying formula:

$$\text{OR} = \text{Models} + \text{Optimization (or Simulation)}$$

Typical features of Operations Research are:

- a broad range of models considered,
- a broad range of objectives taken care of,
- elaborated algorithmic approaches and systems support,
- interfaces with many other disciplines.

The **future of Operations Research is bright**, as long as Operations Researchers are willing to stay close to applications and invest in non-standard modelling and tool frameworks.

2. Some Historical Reminiscences

Late sixties

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Late sixties

- Many important Spanish firms started to recognize the importance of modeling and optimizing their productions processes.
- The advice of the OR groups in the University is required by companies.
- Some leaders in this period were Torrens-Ibern, Chacón, Sixto Ríos, etc.
- Later on, the success of these pioneering applications persuaded the responsible executives of some important companies to create their own OR groups.

Beginning of the seventies

- The OR groups grew and attained their highest activity level. Let us mention here the groups from CEPSA, BUTANO, RENFE, IBERIA, Altos Hornos de Vizcaya, EUSKALDUNA, among many others, as well as the active people in the top of these teams (J. Borrell, J. Domínguez, J.L. Gascó, L. Yu, etc.)

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The last 20 years

- The role of the Spanish universities in providing consulting services to the firms and to the administration, has experimented a definite consolidation.

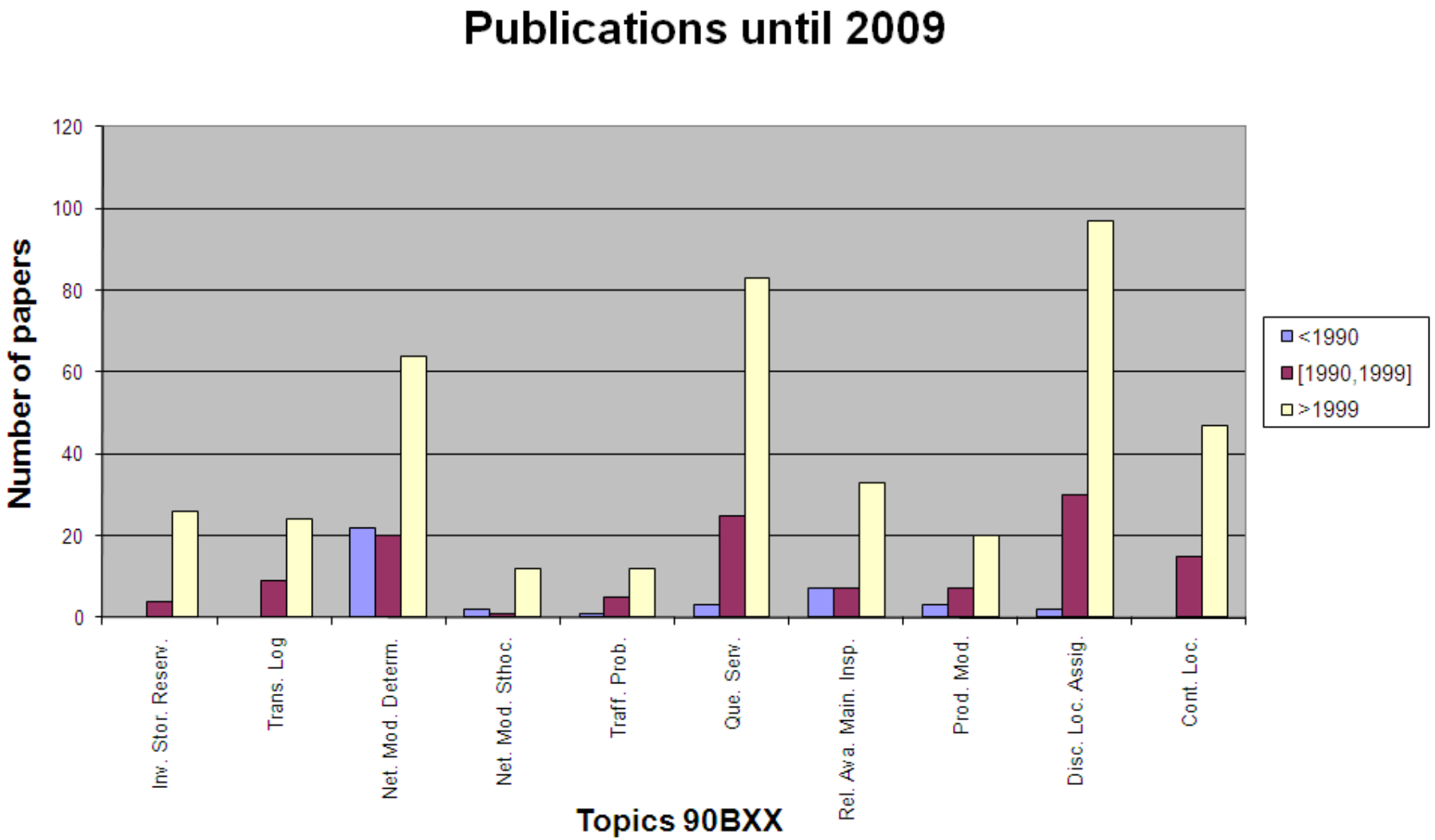
Significant OR applications in Spain

- In "A review of O.R. practice in Spain" (*TOP*, 3 (2), 1995), the authors (M.A.L. and J. Pastor) reported only those projects that gave rise to documented real applications.
- The number of applications reported in this paper are about 40, and they are classified by means of the *application oriented criterion* of the journal *International Abstracts in Operations Research* (*IAOR*).
- Those sections containing more entries are *Manufacturing Industries* (14), *Energy* (5), and *Finance and Banking* (4), accounting for more than the 50% of the reported contributions.
- Most of the research groups that have developed these projects belong to university departments. Very few large corporations in Spain, like CLH and Telefónica, have maintained their own research teams.

Spanish Society of OR

- The *Sociedad de Estadística e Investigación Operativa* (*SEIO*), http://www.seio.es/, was founded on February of 1962, and its goals are to contribute to the promotion and development of the theory, methodology, and application of Statistics and OR.
- SEIO organizes regular meetings (each year and half), and it is a member of international societies (EURO, INFORMS, etc.).
- SEIO publishes a Bulletin (BEIO), and edites two journals:

TEST (http://www.springer.com/statistics/journal/11749), JCR 2008 Impact Factor: 0.930
TOP (http://www.springer.com/business/operations+research/journal/11750), JCR 2008 Impact Factor: 0.694


Publications until 2009
Number of papers
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60
40
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Trans. Log
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Traff. Prob.
Que. Serv.
Rel. Ava. Main. Insp.
Prod. Mod.
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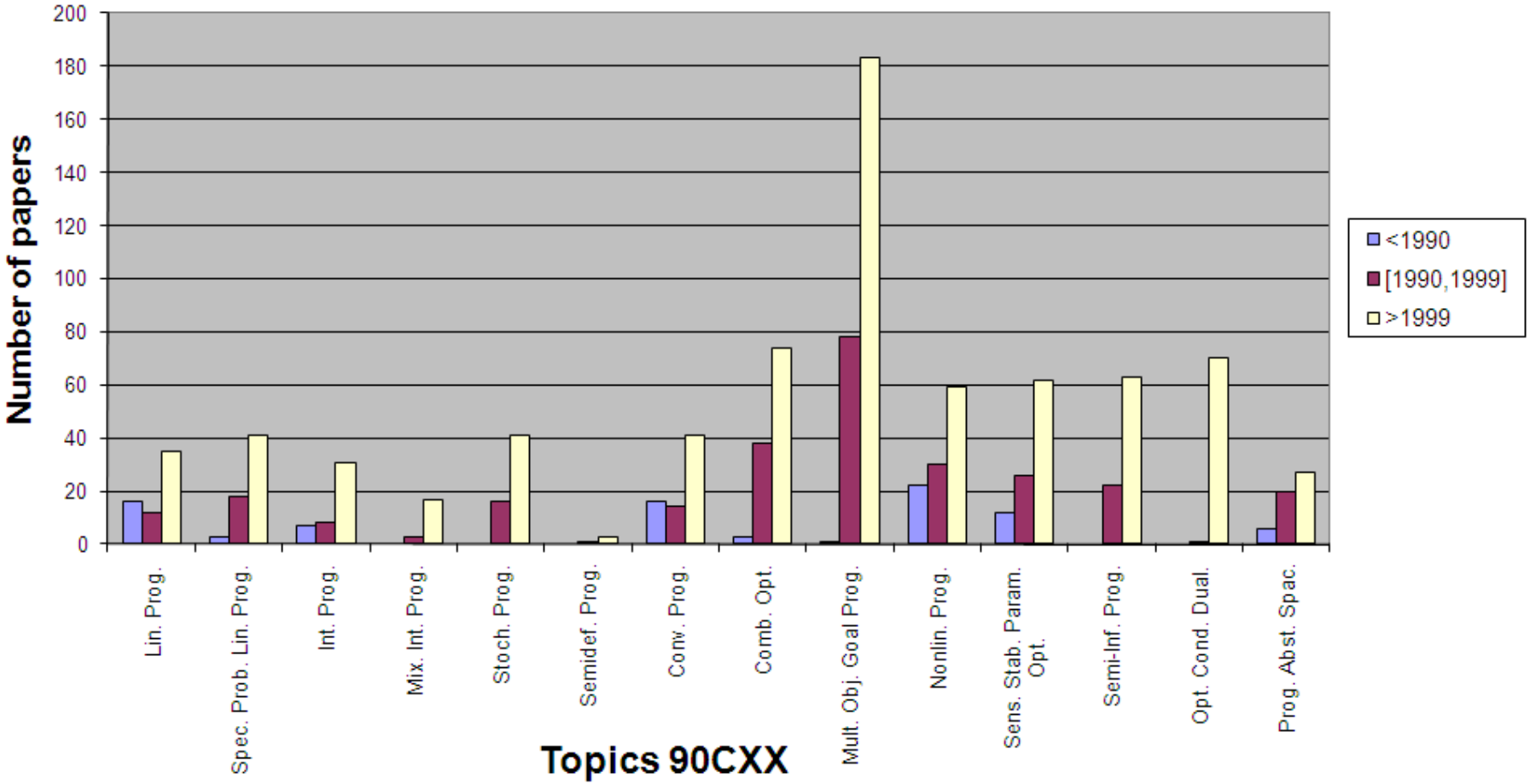
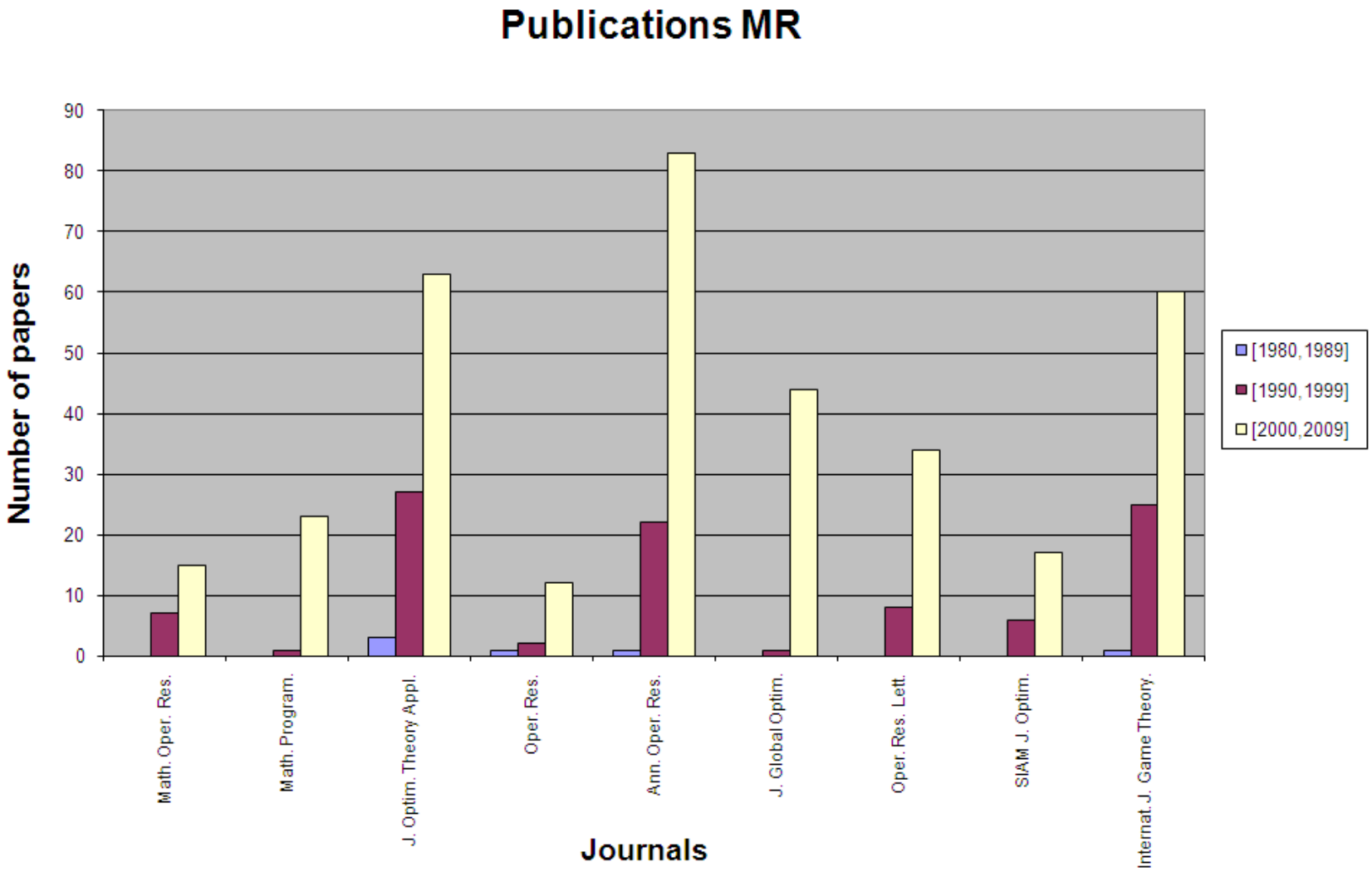
[1990,1999]
>1999

Publications until 2009




Publications MR
Number of papers
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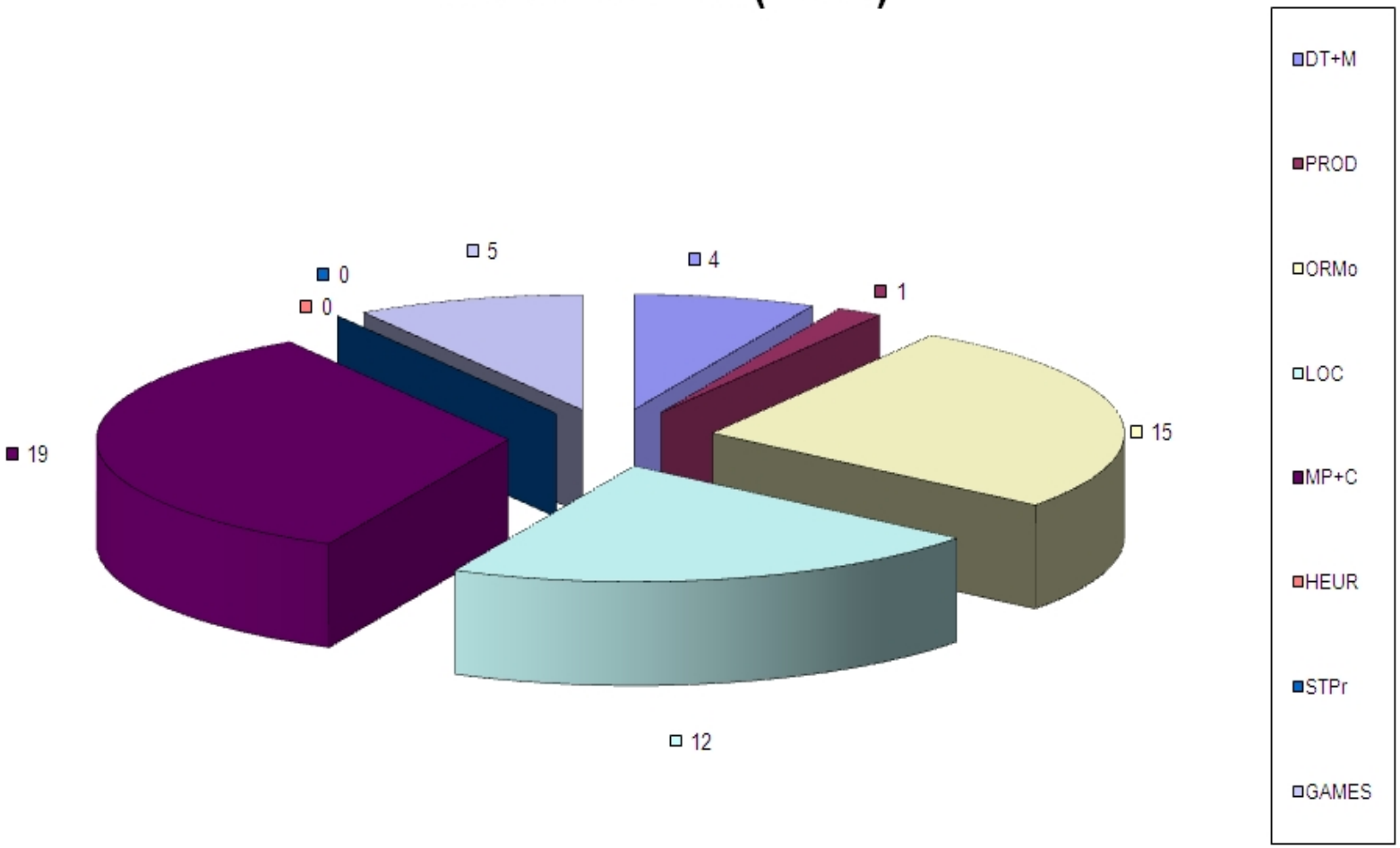
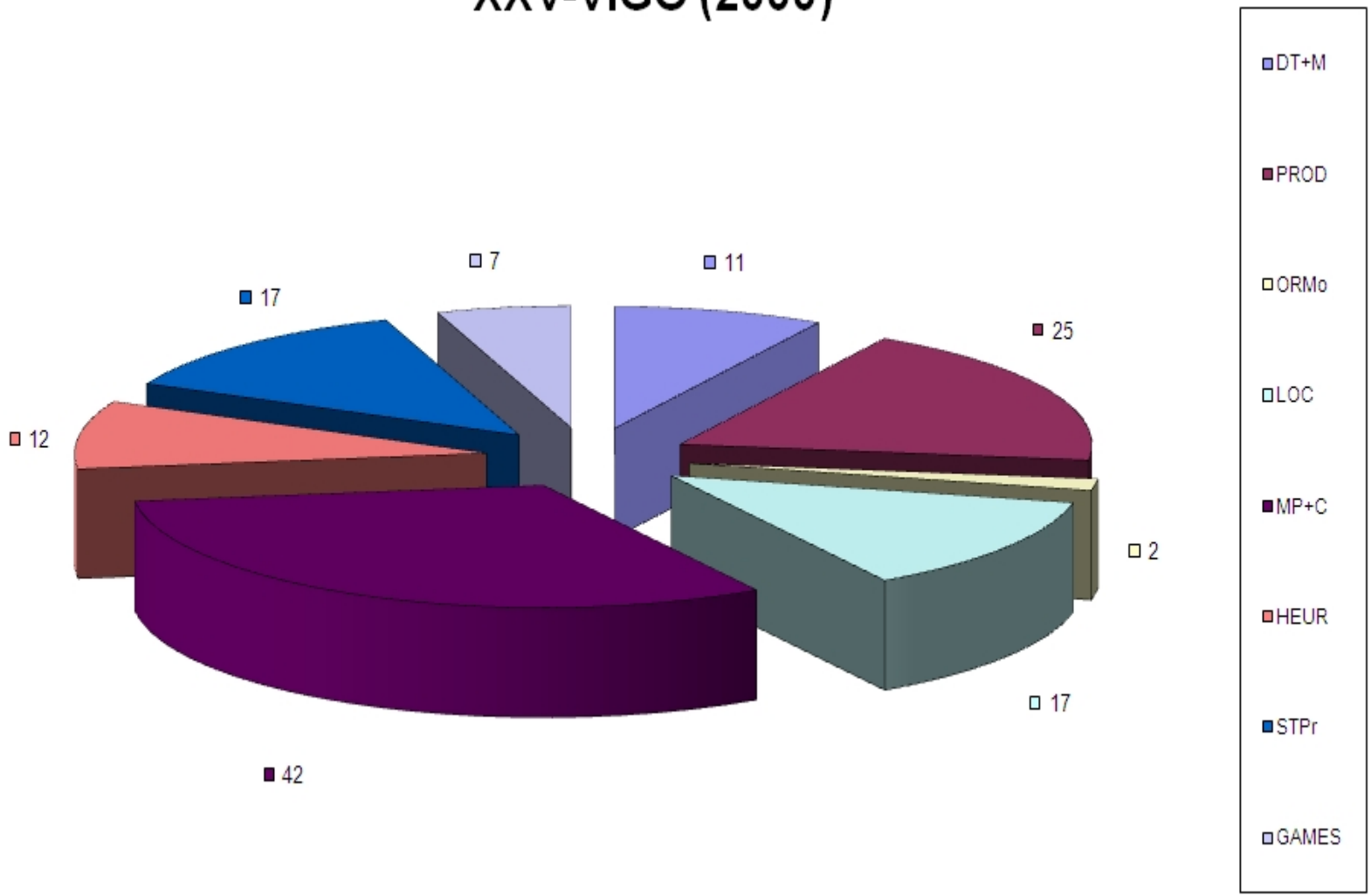
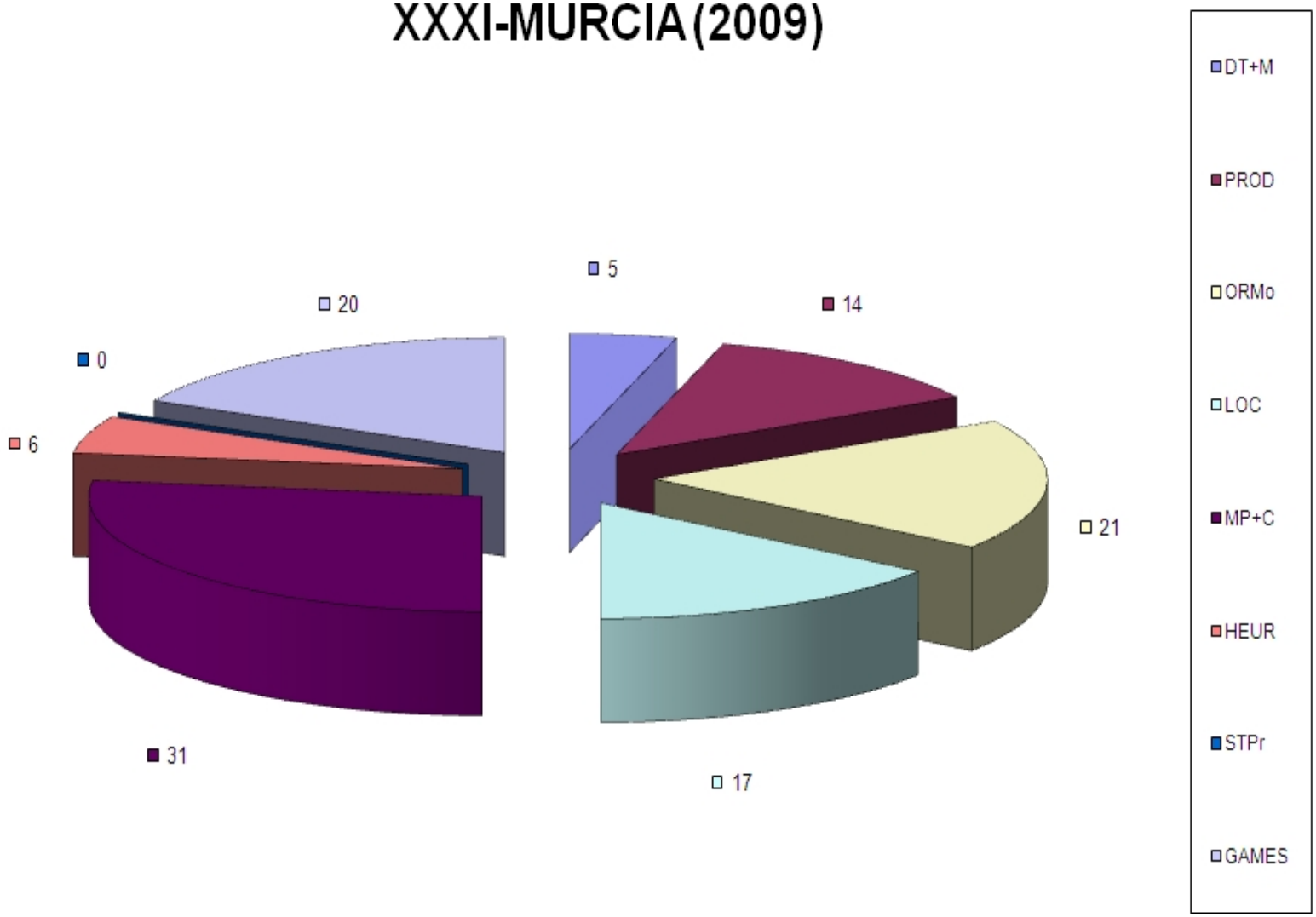
Math. Oper. Res.
Math. Program.
J. Optim. Theory Appl.
Oper. Res.
Ann. Oper. Res.
J. Global Optim.
Oper. Res. Lett.
SIAM J. Optim.
Internat. J. Game Theory.
Journals
[1980, 1989]
[1990, 1999]
[2000, 2009]

XIX-SEGOVIA (1991)



XXV-VIGO (2000)




XXXI-MURCIA (2009)
5
14
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0
6
21
31
17
DT+M
PROD
ORMo
LOC
MP+C
HEUR
STPr
GAMES

Research Topics with High Social Impact that Are Relevant also for Operations Research:

- The Human Genome Project
- Multimedia and animation as a learning framework
- Service Robotics

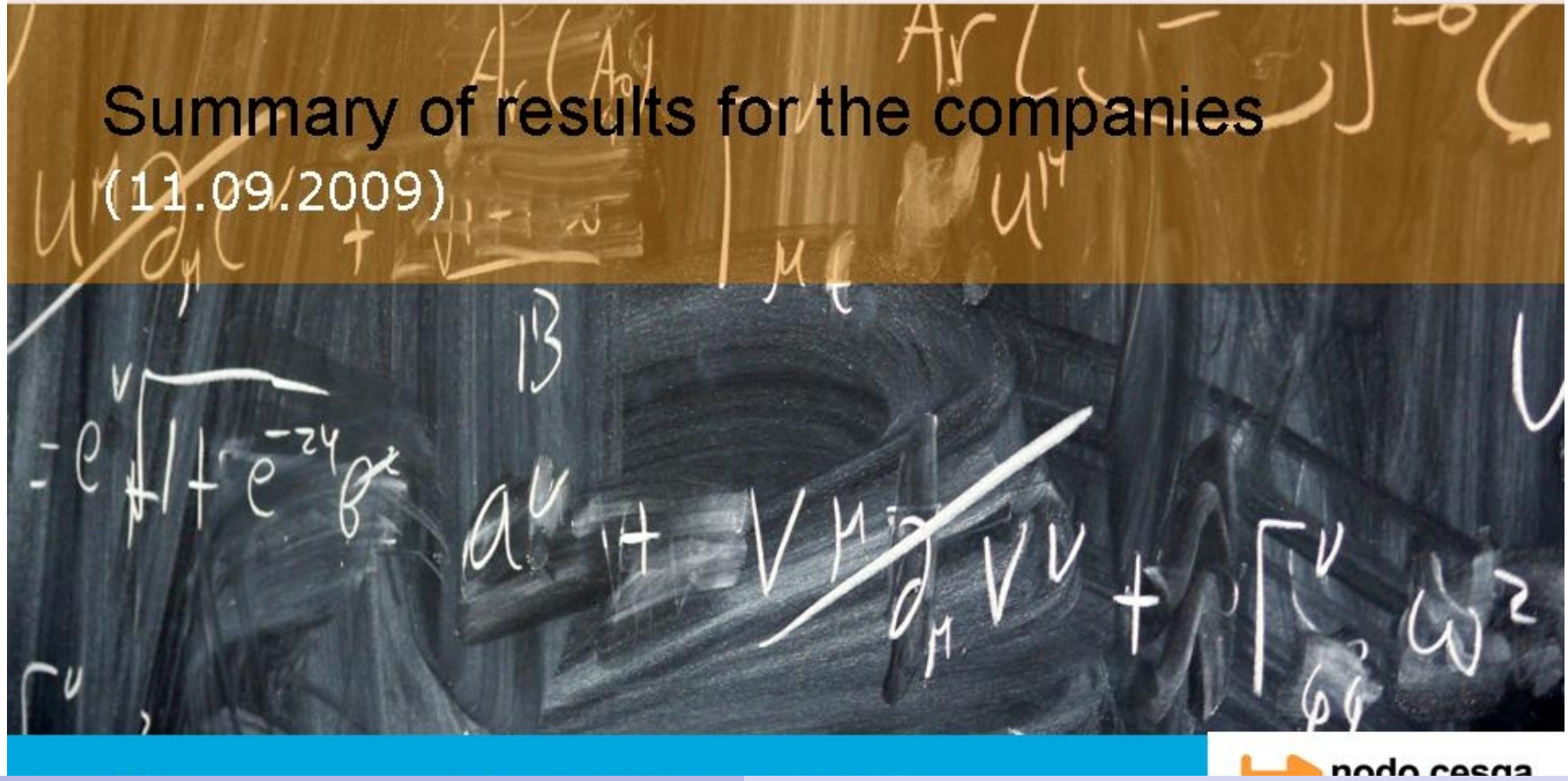
Some Important Topics for Operations Research for the Future:

- Optimisation will further gain importance
- Planning, scheduling and logistics will be employed in more and more fields
- Formal decision making, preferences, game-theoretic aspects come strongly into the picture
- Education, investing in human resources and capacity building will become central issues
- Neural networks, learning systems and genetic algorithms open up new paradigms
- Processing multimedia content is an important issue.

i-math ingenio mathematica consolider ingenio2010

TransMATH

i-MATH map of demand of mathematical technology



Summary of results for the companies (11.09.2009)

nodo cesga

Introduction I

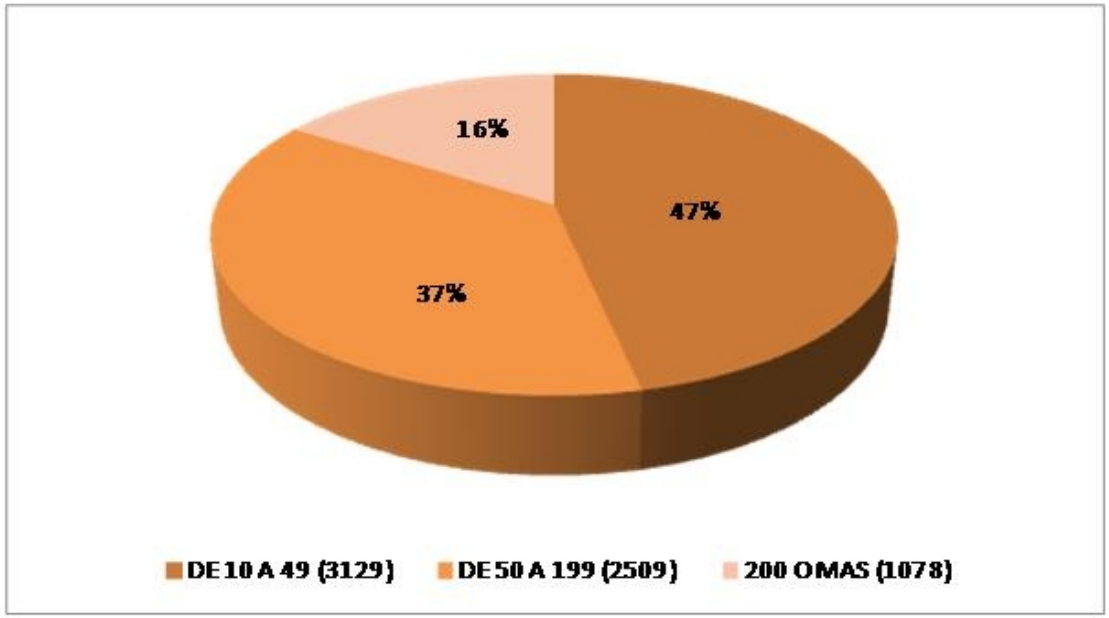
- The main goal of the Action i-MATH ANALYSIS OF THE COMPANY DEMAND OF MATHEMATICAL THECNIQUES is to detect needs and problems in different Spanish business sectors in which the Mathematics could be a fundamental or complementary tool.

- As a part of the Action, i-MATH performed the study of the companies from a telephonic survey to the set of the Spanish companies. They interviewed to 6.716 companies with more than 10 employees and to the practical totality of the business sectors.

- This document presents the main results. The document is going to be distributed to the companies participants.

The sample of companies

Distribution of the sample by company size

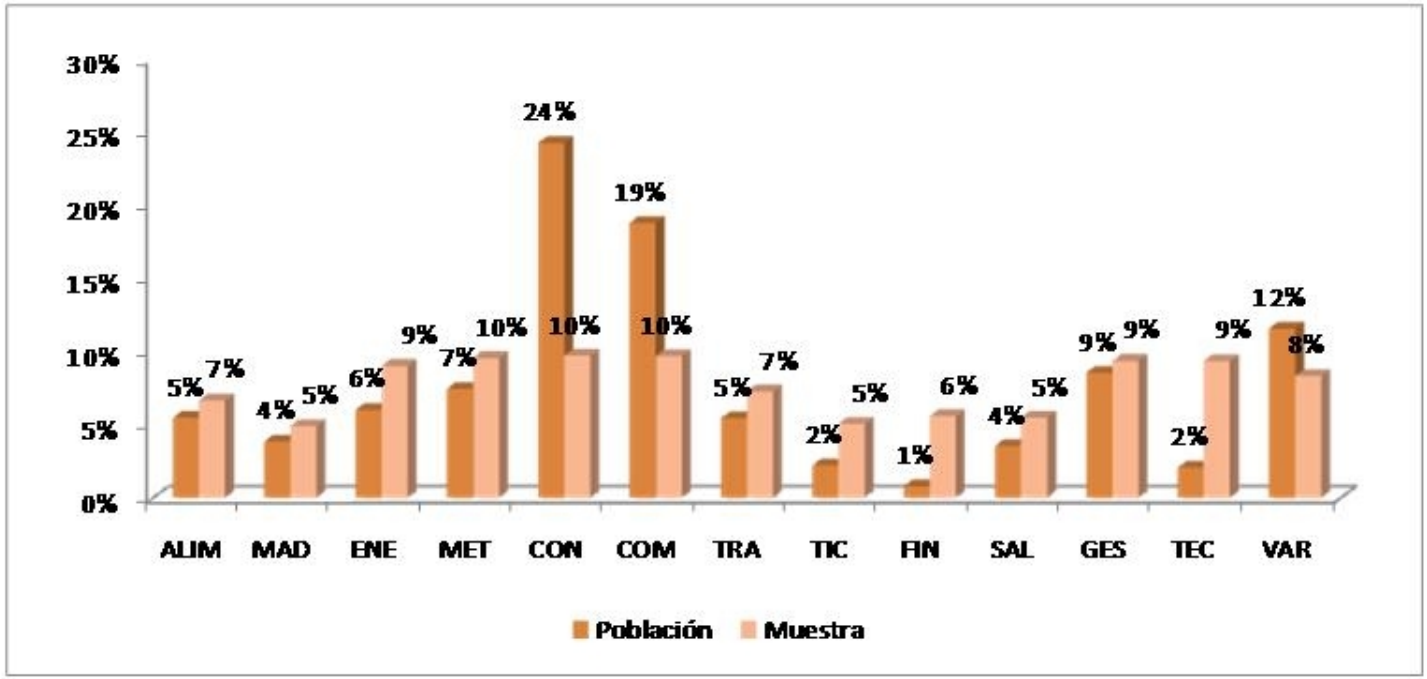


Base: All companies

Source: i-MATH Project. TrasMATH Demand Map, 2009.

The Sample of Companies

Distribution of the sample by activity sectors

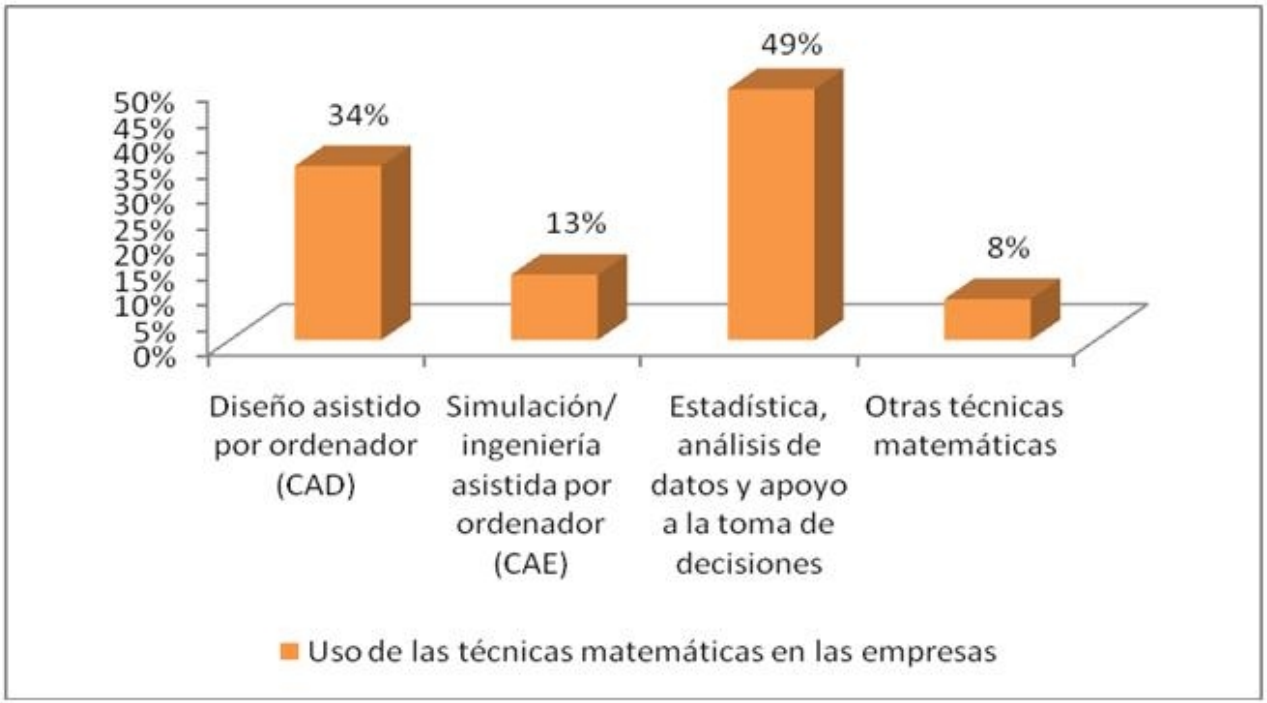


Base: All companies

Source: i-MATH Project. TrasMATH Demand Map, 2009.

Main Results

Use of the mathematical techniques in the companies

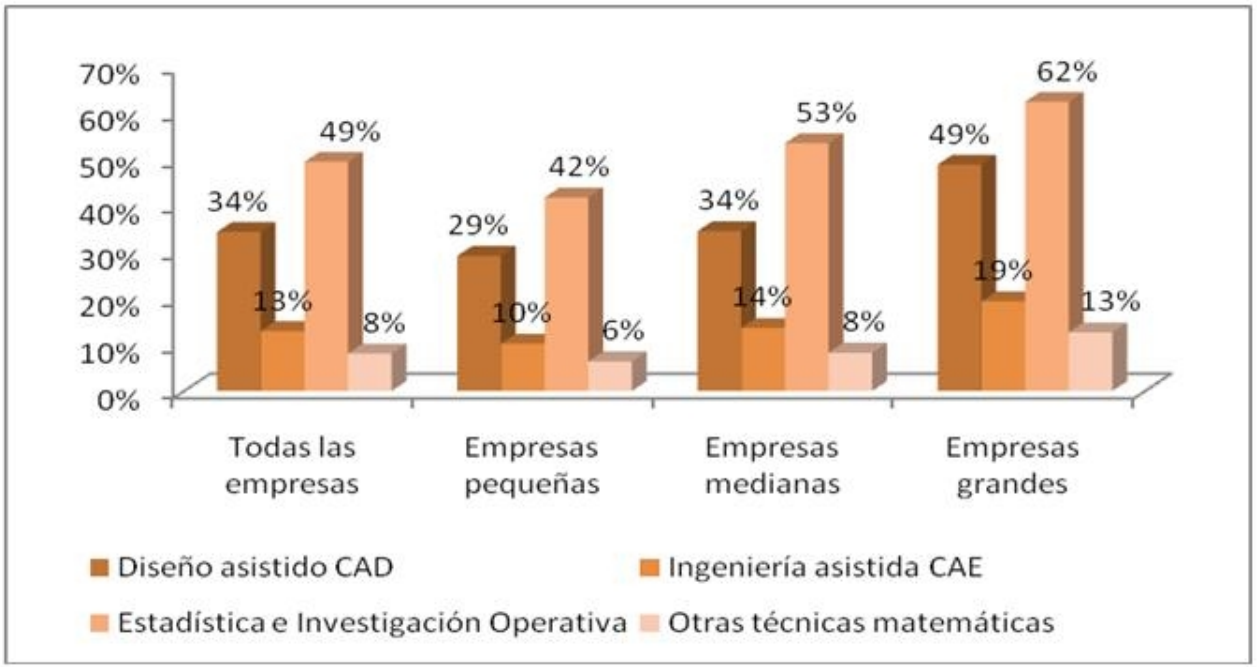


Base: All companies

Source: i-MATH Project. TrasMATH Demand Map, 2009.

Main Results

Use of mathematical techniques by company size

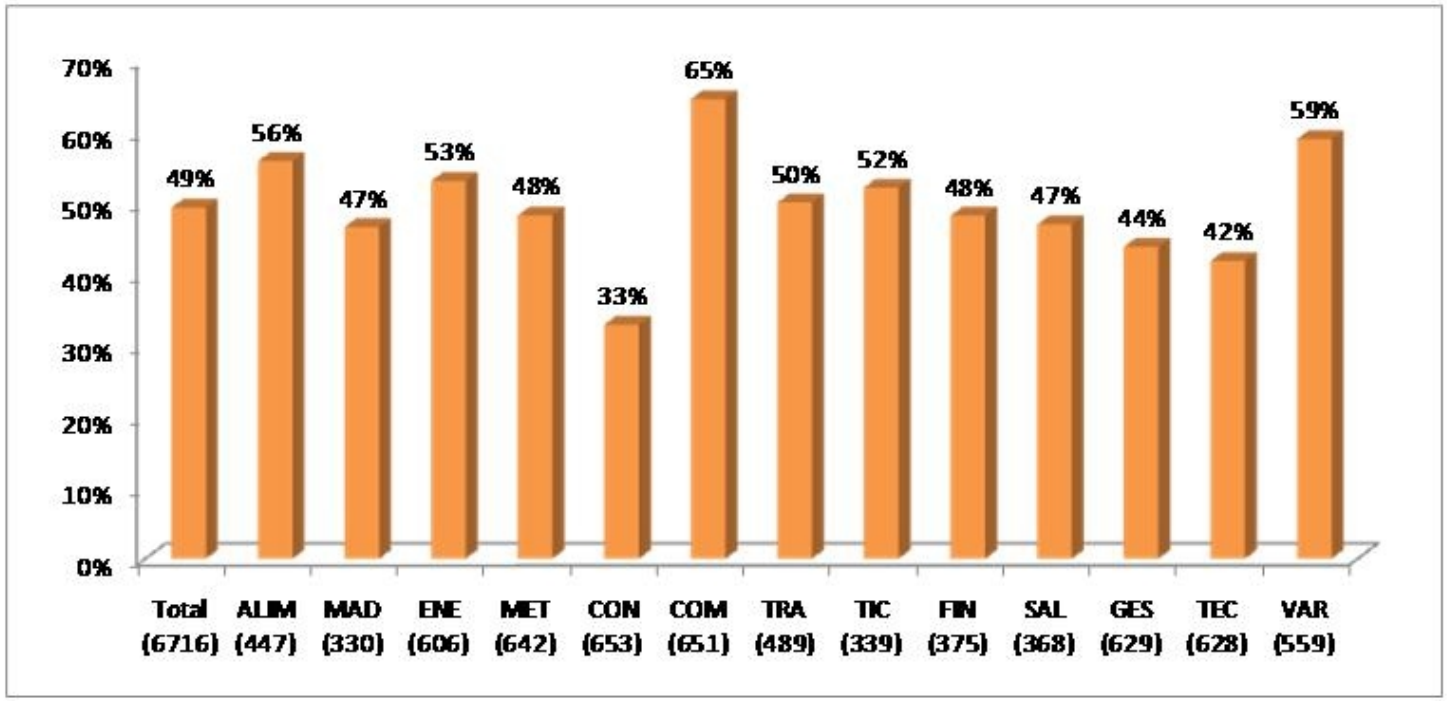


Base: All companies

Source: i-MATH Project. TrasMATH Demand Map, 2009.

TEIO

Use of statistical techniques, data analysis, and operations research by sectors

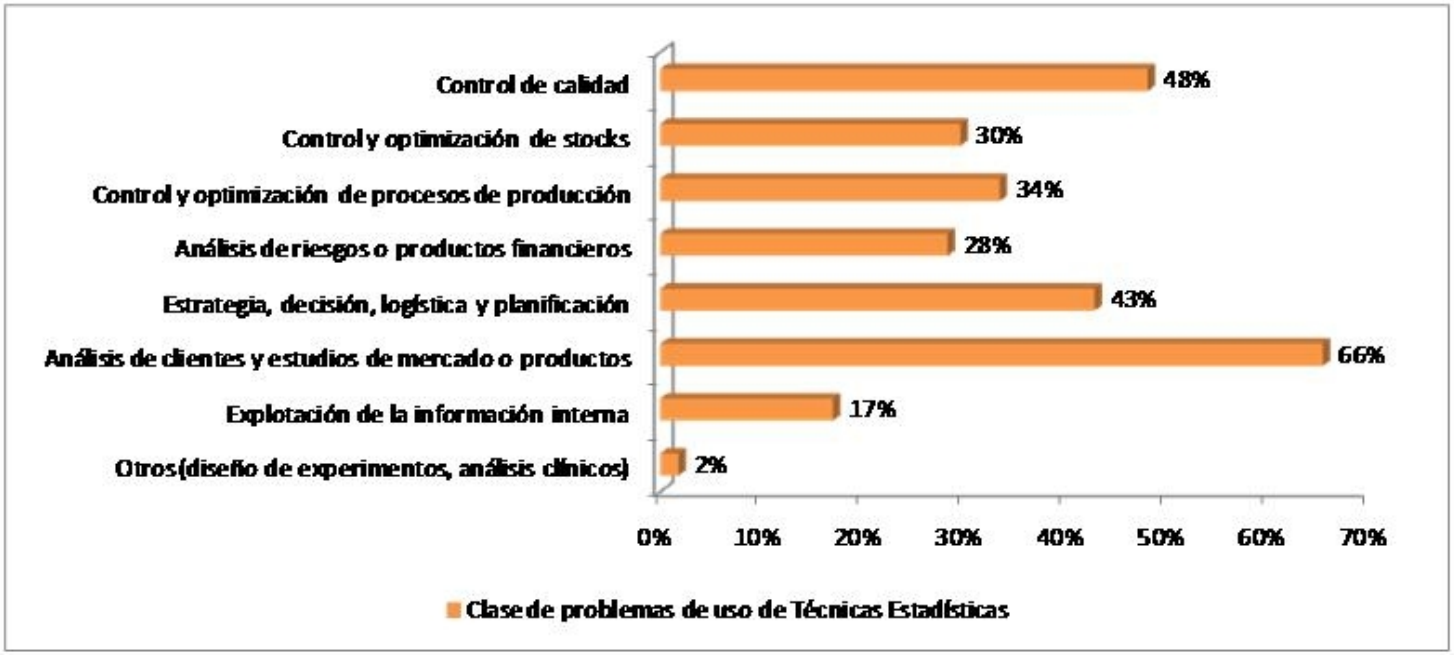


Base: All companies

Source: i-MATH Project. TrasMATH Demand Map, 2009.

TEIO

Topics in which are used statistical techniques, data analysis, and operations research



Base: User companies of statistical techniques, data analysis, and operations research.
Source: i-Math Project. TrasMATH Demand Map, 2009.

Project: Consolider i-MATH

Marco Antonio López Cerdá

University of Alicante

Aims

Ingenio MATHEMATICA (i-MATH) is a CONSOLIDER singular research project for the period 2006-2011.

It proposes a complete activity research program for Spanish mathematics, with the purpose of promoting and carrying out strategic actions that, qualitatively and quantitatively, increase the presence of Spanish mathematics in the international system of science, technology, business, etc.

i-MATH is an initiative promoted and financed by the Spanish Ministry of Education and Science with a budget of 7,500,000 €.

The official start of the i-MATH project is the 3rd of October, 2006.

Aims

- To improve the role of mathematical research in the Spanish system of science, technology and innovation.

- To increase and promote the activities of transference of knowledge and technology of the Spanish mathematicians.

- To promote the use of computational methods both inside and outside mathematical research.

- To achieve greater recognition for Spanish research groups at an international level and to increase the presence of Spanish mathematicians in strategic areas.

- To create a Doctorate School of international status.

- To use research and innovation to improve education and mathematical training at all levels.

- To make the results of mathematical research more accessible both from within and from outside Mathematics.

Tools

Platforms:

1. **FUTURE**
2. **CONSULTING**
3. **COMPUTING**
4. **EDU**
5. **WEB**

Thematic actions:

6. **i-MATH International Graduate School (MIGS)**
7. **i-MATH Intensive Research Programs (PMII)**

Cross-sectional Services of Support:

8. **Service of Support to the Organization of Encounter and Meetings (SARE)**
9. **Service of Support to the Institutes of Research and the Thematic Networks(SAIRT)**
10. **Web i-MATH**

(www.i-math.org)

Research Program

A. From basic research to applications

A.1. Enigmas to decipher: Fundamental Mathematics and Cryptography.
A.2. From Classical Analysis to the digital era.
A.3. New frontiers in Algebra and Geometry.

B. How to understand the physical world

B.1. From Geometry and Topology to Physics and Cosmological models.
B.2. Mathematics, Dynamics and Complexity.
B.3. Partial Differential Equations as a tool for modeling.

C. The essential computational support

C.1. Intelligent structures and materials: Design & control.
C.2. Math software: Mathematics as the basic foundation for Scientific and High Performance Computing.
C.3. New techniques and horizons in Computational Mathematics.

D. Direct applications to society

D.1. Mathematics and the information society and communications.
D.2. Statistical models and their applications.
D.3. Stochastic modeling of complex evolving phenomena and configurations in random media.
D.4. Optimization and decision-making support techniques.
D.5. New horizons in Mathematics education and training.
D.6. Bringing Mathematics closer to society.

Organization Chart

Research Coordinator:

- Marco Antonio López Cerdá (Univ. Alicante)

Management Center:

- University of Cantabria

Steering Committee

Nodes:

- CESGA, CIEM, CRM, ICMat, IMUB

Node Committee

Platform Committees

Research Groups: 330 (1.738 researches)

Steering Committee

Joaquim Bruna (Universidad Autónoma de Barcelona)
María Jesús Carro (Universidad de Barcelona)
Eduardo Casas (Universidad de Cantabria)
Antonio Durán (Universidad de Sevilla)
Ángel Jorba (Universidad de Barcelona)
Manuel de León (CSIC)
Marco Antonio López-Cerda (Universidad de Alicante)
Ignacio Luengo (Universidad Complutense de Madrid)
Consuelo Martínez (Universidad de Oviedo)
Gabriel Navarro (Universidad de Valencia)
Peregrina Quintela (Universidad de Santiago de Compostela)
Francisco Santos Leal (Universidad de Cantabria)
Luis Vega (Universidad del País Vasco)

Operation

Nodes Action Plan

Top-down Activities

i-MATH Calls:

- 5 General Calls
- 1 call of 'Contratos flechados'
- 2 calls for FUTURE i-MATH appointments

Some i-MATH Activities

i-MATH CONSULTING

Operations Research for the management of agricultural cooperatives and location of services.

Forums of interaction with the industry: automotion, biomedicine, finance, environment, etc. (CESGA).

i-MATH FUTURE

Optimal aerodynamic design from innovative mathematical and computational techniques (ICMAT).

Nonlinear dynamics of geophysical flows.

Mathematical modeling of transfers phenomena of mass in food technology.

Stochastic models and decision theory for the detection and prediction of internet failures.

Inter-Consolider meeting: 'Consolider ARES & Consolider i-MATH'.

Some i-MATH Activities

i-MATH INTERNATIONAL GRADUATE SCHOOL

SIMUMAT Summer School 2007 and 2008 – (ICMAT-CIEM).

International Summer School on Geometry, Mechanics and Control (CIEM).

i-MATH Graduate School of Mathematical Programming and its Applications (CIEM).

i-MATH PROGRAMS OF INTENSIVE RESEARCH

Mathematics and Digital Data Security (CRM).

Enumerative Combinatorial Analysis and Random Structures (CRM).

Control Mathematics and Information Theory (ICMAT-CIEM).

Some i-MATH Activities

i-MATH COMPUTING

Development of the i-MATH GRID (CESGA+IMUB).

Singular challenges in computation (CESGA).

Training courses in computing, linear numerical algebra, algebraic manipulators, parallel programming, etc.)

i-MATH EDU

InterGEO-Spain meeting (CIEM): "Kick-off meeting of the InterGEO European Project"

Support to ESTALMAT

Further Information

http://www.i-math.org:

- Documentation.
- Researchers.
- News
- Calls
- Communication bureau
- Activities

E-mail:

- i-math@unican.es

Thank you