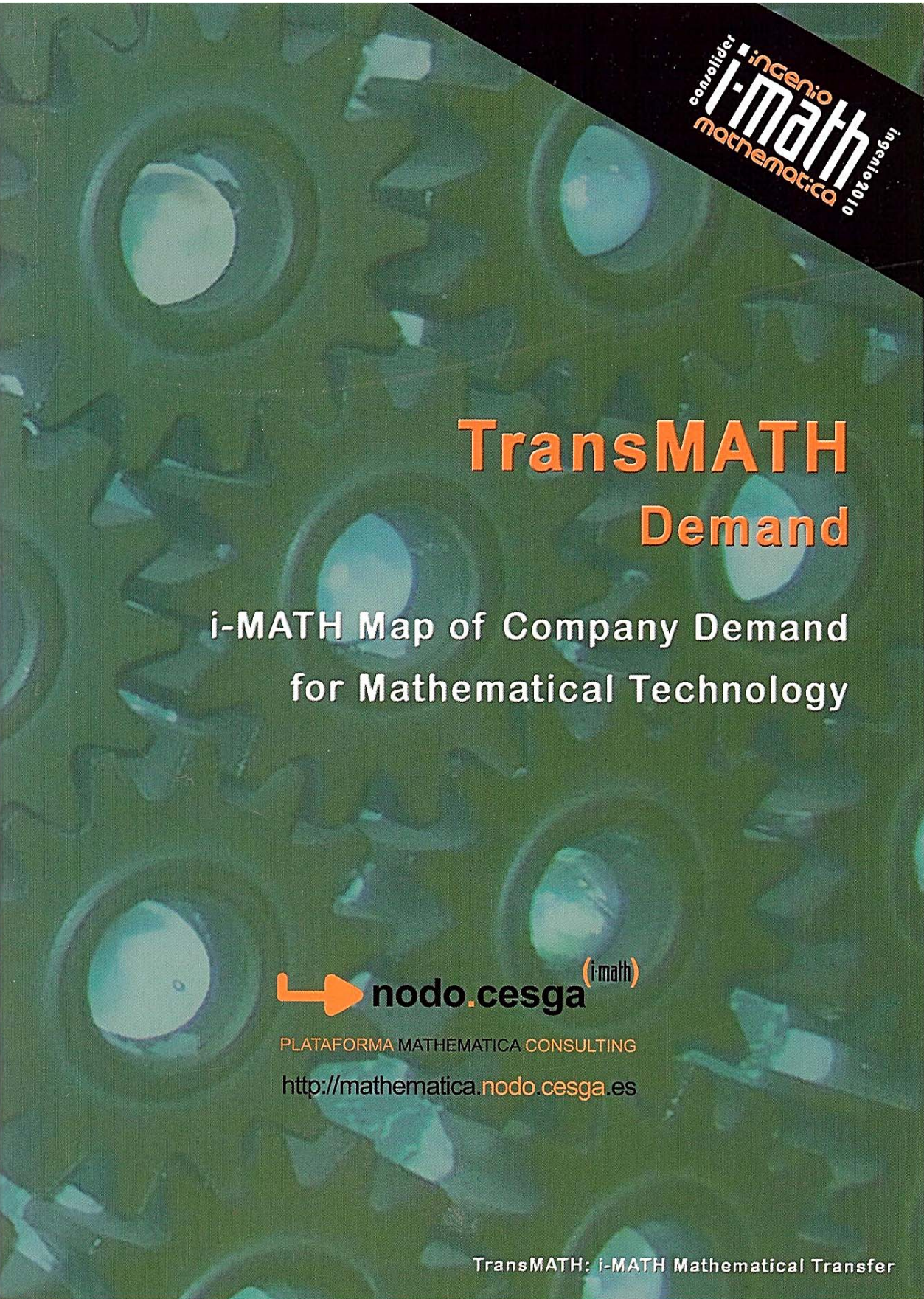

TransMATH
Demand

i-MATH Map of Company Demand for Mathematical Technology

nodo.cesga (i-math)

PLATAFORMA MATHEMATICA CONSULTING

http://mathematica.nodo.cesga.es

i-MATH MAP OF COMPANY DEMAND FOR MATHEMATICAL TECHNOLOGY

TransMATH

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TransMATH is an initiative of the Consolider i-MATH project via the *Nodo CESGA*

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1 INTRODUCTION

A proposal for an integral Research Activity Program for Spanish mathematics is made through the *Consolider Ingenio Mathematica* project (i-MATH, 2006-2011, http://www.i-math.org), with the basic aim of promoting and conducting state-wide strategic action to further the presence of mathematics both qualitatively and quantitatively at an international level as well as within the Spanish system of science, technology and business.

In order to take this step, several initiatives are under way through i-MATH to determine the current situation of Spanish mathematics and to detect its strengths and weaknesses, with the purpose of acting upon those aspects where it is found to be lacking in comparison with its current state of economic development, and to continue making progress in those areas and subjects where it already enjoys a relevant or consolidated international position.

Among these initiatives is Ingenio MATHEMATICA Map of Technology on Offer (Oferta TransMATH),

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

which analyses the experience acquired in technology transfer to business and industrial sectors by the research groups belonging to the i-MATH project; in particular, this TransMATH *Mapa de Oferta* enables the capacity of and experience in the transfer of mathematical technology to be viewed from the outside, as well as attaining synergies among the research groups involved in the project for getting new initiatives under way. This map is now completed with the appearance of this present document, the Map of Demand for Mathematical Technology (*Demanda TransMATH*), which details a national prospectus on the level of knowledge, use and demand for mathematical technology by commercial companies.

The purpose of both maps of technological supply and demand, as well as the subjects they cover, is described in the following article of the *Implementation Agreement* that was signed with the Spanish Ministry of Science and Education to mark the start of the i-MATH project:

"The design and annual update, together with the validation by an independent panel external to the i-MATH project, of a map showing the interactions and connections (both extant and possible) between mathematical research and the transfer of technology to the business and industrial sectors. The map will pay special regard to the detection of deficiencies that need to be addressed in emerging fields, to

the strengthening of existing fields, and to the discovery of latent scientific-technological opportunities to be developed. "

For the drawing up of this TransMATH Map of Demand, and in collaboration with the i-Math Board of Directors (BD), the *Nodo CESGA* (http://mathematica.nodo.cesga.es/) set in motion a project for detecting problems in the corporate field for which Mathematicians could provide the complementary or fundamental tools, determine the demand for mathematical training, and define where necessary new lines of research in Mathematics aimed at solving these problems. This project constitutes a highly ambitious, path-finding venture, unique in the field of Mathematics, in which a survey has been carried out on some 8,000 companies of more than 10 employees, distributed throughout Spain and representing all industrial and business sectors. To this end, a Panel of Experts from the academic, business and industrial sectors, as well as from technological centers, have provided their advice and expertise. Specialists in CAD, Numerical Simulation, Statistics, Operations Research and other fields of Mathematics have participated in this panel, all with experience in the transfer of technology to companies. In addition to experts in Consulting at the Nodo CESGA, their counterparts in Consulting at the Department of Statistics and Operations Research from the University of Santiago de Compostela have also participated in the post-process.

Funding for this TransMATH Map of Demand has come from the Spanish Ministry of Science and Education through the Consolider i-MATH CSD2006-00032 Project, from the *Complementary Action* MTM2007-30179-E of the *Xunta de Galicia* (Autonomous Government of Galicia) via the agreement dated 16/10/2007, from the *Red Mathematica Consulting & Computing de Galicia*, from the *Centro de Supercomputación de Galicia* (CESGA) and from the University of Santiago de Compostela (USC).

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Santiago de Compostela, December 2009.

2 OBJECTIVES AND METHODOLOGY

2.1 Objectives

The main objective of the i-MATH ANALYSIS OF COMPANY DEMAND FOR MATHEMATICAL TECHNIQUES undertaking is to detect the requirements and problems in different Spanish corporate sectors where mathematics can act as either a fundamental or complementary tool; to determine the demand for mathematical training and to define, where required, new research lines in Mathematics aimed at solving these problems.

In order to carry out this study, a wide-ranging sample of companies distributed throughout the country has been taken with the aim of identifying the level of knowledge, use, satisfaction and need for training in:

- Computer-Assisted design (CAD),
- Numerical simulation or Computer-Assisted Engineering (usually known as CAE),
- Statistical and Operations Research tools (ST/OR),
- Other mathematical Techniques applicable to industry (OMT),

as well as company preferences as regards the formalization of collaboration between companies and universities and between companies and research centers.

More specifically, the objectives of the i-MATH ANALYSIS OF COMPANY DEMAND FOR MATHEMATICAL TECHNIQUES are as follows:

1. To make known the benefits of mathematical techniques for small, medium-sized and large companies.
2. To explore more deeply the different uses and applications that can be made available for representative sectors of the Spanish economy.
3. To determine company needs and requirements concerning the incorporation of qualified human resources into the field of mathematics.
4. To detect training requirements in the field of mathematics, statistics and operations research.
5. To identify the lines of research of interest for companies in this field.
6. To detect the barriers existing for the adoption of these techniques by companies.

7. To identify the predisposition and opportunities for collaboration between companies and Universities and Research Centers.
8. To make known to the mathematical community the needs of the business world in this field.

2.2 Methodology

In order to carry out the i-MATH ANALYSIS OF COMPANY DEMAND FOR MATHEMATICAL TECHNIQUES, a survey was conducted over the telephone. Two samples were designed: the first consisting of 6,716 companies of a general nature, and the second consisting of 801 companies in sub-sectors of particular relevance in the use of mathematics.

Field work was carried out between March 24th and July 30th 2009. The field report and detailed methodology of the two samples under consideration are available at the following website: http://www.imath.org/mapa_demanda and are described in a separate document entitled *Informe Técnico del Mapa TransMATH Demanda* (TransMATH Demand Map Technical Report).

Geographically speaking, the survey covered the entire national territory with the exception of Ceuta and Melilla.

As regards the statistical purpose of the data, the survey was designed for analysis of the sample according to Autonomous Communities, sector of activity and size of company, all of them aspects of particular interest in this study.

The *Directorio Central de Empresas* (DIRCE) of the *Instituto Nacional de Estadística* (INE – National Institute of Statistics) was adopted as the basis of the universe, updated as of January 1st 2008. The classification system for economic activities employed was the CNAE-2009, recently updated to adapt to the new economic reality and structured harmoniously with the rest of European Union countries.

The following divisions were excluded from the sectors of economic activity (CNAE-2009) in this study:

- 01, 02 and 03 (*Agriculture, cattle raising, forestry and fishing*).
- 84 (*Public Administration and Defence*).
- 85 (*Education*).
- 97 (*Home activities as employers of domestic service*).
- 98 (*Home activities as producers of goods and services*).
- 99 (*Activities of organizations and bodies outside of Spain*).

These divisions correspond either to economic activities that are not usually included in business studies or to companies whose main activity is in education. The main reason for ruling out these latter was that although such companies may be intensive users of mathematics, collaborations with this activity group are not considered to be actions of transfer. Sections 01, 02 and 03 are indirectly included in other CNAE codes,

such as *Food and Clothing. E*xclusion of the above-mentioned divisions enables efforts to be concentrated on the remaining activities.
The universe is structured into 13 activity groups according to the different CNAE-2009 codes, as can be seen in Table 2-1 below.

CNAE	Sector	Code
10-15	*Food and clothing*	**FOOD**
16-18, 31	*Timber and paper*	**TIM**
05-09,19-23, 32-33, 35-39	*Energy, chemical and environment*	**ENE**
24-30	*Metal and machinery*	**MET**
41-43	*Construction*	**CON**
45-47	*Commerce*	**COM**
49-53	*Transport and storage*	**TRA**
58-63	*Information and Communication Technology (ICT)*	**ICT**
64-66	*Finance*	**FIN**
75, 86-88	*Health*	**HEA**
69-70, 77-82	*Management services*	**MAN**
71-74	*Technical services*	**TEC**
55-56, 68, 90-96	*Miscellaneous services*	**MISC**

Table 2-1: Structure of the universe by interest sector.

The total number of companies making up the universe described amounts to 195,098; their distribution, according to sector and the number of employees in each one, is shown in Table 2-2.
As far as division by sector is concerned, those regarded as being of special importance appear against an orange background in Table 2-2, in accordance with the foreseeable applicability of mathematical techniques, while those shown against a blue background on are regarded as sectors with a more limited applicability.

Sector	From 10 to 49	From 50 to 199	More than 199	Total
Food and clothing	9,001	1,328	330	10,659
Timber and paper	6,624	758	116	7,498
Energy, chemical and environment	9,278	1,884	540	11,702
Metal and machinery	12,000	1,948	559	14,507
Construction	42,197	4,415	733	47,345
Commerce	32,292	3,573	843	36,708
Transport and storage	9,144	1,163	293	10,600
ICT	3,305	717	296	4,318
Finance	1,085	273	241	1,599
Health	5,234	1,199	465	6,898
Management services	12,185	1,897	921	15,003
Technical services	4,816	655	239	5,710
Miscellaneous services	19,244	2,653	654	22,551
Total	**166,405**	**22,463**	**6,230**	**195,098**

Table 2-2: Distribution of the universe by sector and in each sector by company size.
Source: INE. *Directorio Central de Empresas* (DIRCE). January 2008.

2.2.1 Sample

The size of the sample was 6,716 companies.
The type of sample employed is random sampling, with segmentation by:

- Size of company: composed of three groups; the first, companies employing between 10 and 49 people; the second, between 50 and 199 employees, and the third with more than 200 employees.
- Sector of activity: the thirteen different groups are shown in Table 2-1.
- Geographical location: corresponds to each of the 17 autonomous communities in Spain.

As regards company size, affixation of the sample is not performed in a proportional way among the three employee strata, since on the one hand similar levels of error in all of them were sought, while on the other the group of large size companies was considered to be of great interest for the project.
Once the size of each employee stratum of was established, the affixation in each of the thirteen strata of economic activity was performed, paying special attention to those groups regarded as being of greatest interest. These are as follows: *Energy, chemical and environment; Transport and storage; Finance; Health, and Technical services.* The minimum affixation of 331 companies corresponds to the timber sector.

Once the sample corresponding to each of the thirteen economic activity groups was determined, and for each of the three groups of companies according to number of employees, affixation by autonomous community was proportional to the universe.
The following tables show the distribution of the sample and of the universe according to the number of employees, sector and autonomous community.

Nº of employed	Sample	Universe
From 10 to 49	3,129	166,405
From 50 to 199	2,509	22,463
200 OR MORE	1,078	6,230
Total	6,716	195,098

Table 2-3: Distribution of the sample and the universe by company size.

Sector	Sample	Universe	Sector Name
FOOD	447	10,659	***Food and clothing***
TIM	331	7,498	***Timber and paper***
ENE	606	11,702	***Energy, chemical and environment***
MET	642	14,507	***Metal and machinery***
CON	653	47,345	***Construction***
COM	651	36,708	***Commerce***
TRA	489	10,600	***Transport and storage***
ICT	339	4,318	***ICT***
FIN	375	1,599	***Finance***
HEA	368	6,898	***Health***
MAN	629	15,003	***Management services***
TEC	628	5,710	***Technical services***
MIS	559	22,551	***Miscellaneous services***

Table 2-4: Distribution of sample and universe by sector.

Auton. Com.	Sample	Universe
Andalucía	820	28,304
Aragón	210	5,762
Asturias	124	3,535
Balearic Islands	137	4,974
Canary Islands	228	8,242
Cantabria	68	2,178
Castilla La Mancha	212	7,710
Castilla y León	270	8,560
Cataluña	1,310	37,891
C. Valenciana	708	22,451
Extremadura	82	3,173
Galicia	359	10,252
Madrid	1,418	30,199
Murcia	191	6,763
Navarra	119	3,106
Basque Country	418	10,469
Rioja	43	1,529

Table 2-5: Distribution of sample and universe by Autonomous Community.

In short, rather than basing the selection criteria for the sample size by stratum on optimality criteria, (proportional sampling, minimum variance, etc.), population distributed by company size, sector and Autonomous Community was considered instead, as well as subjective criteria based on the transfer experience of the Map's Panel of Experts in order to guarantee a reasonable representation of sectors and sizes of companies regarded as being the most strategic for this study. It is for that reason that in this edition of the TransMATH Map of Demand a descriptive treatment of the sample data has been chosen, leaving the analysis of its inference on the population for later work, should this be necessary.

Zoom sample

The aim here was to define a sample especially oriented towards those sub-sectors in which there is at present a significant degree of mathematical technology transfer, and which may not have been sufficiently represented in the general sample. For this zoom sample, 801 further surveys were carried out in addition to those already conducted for the general study in the afore-mentioned sub-sectors (see Table 2-6), giving a total sample of 1,591 companies.

Subsector Code	CNAE Code	Sample & zoom	Subsector
MET2	24-25,29-30	978	***Metal and machinery***
ENE2	35-39	161	***Energy & environment***
R+D	72	149	***Research & development***
HEA2	86	303	***Health***
Total		**1,591**	

Table 2-6: Distribution of the zoom sample by sub-sector.

As regards the R+D sub-sector, included in the zoom sample was a new employee segment (from 3 to 9 employees) that did not figure in the main study. This exception was made because the CNAE-2009 72, which corresponds to *Research and Development* activity, plays a key role in the project, as well as the fact that in the configuration of companies in this division, those with fewer than 10 employees have a significant importance within the total. Companies employing fewer than 3 people were not included in the general sample, since it is an extremely complex task to obtain details of these types of micro-companies from commercial telephone directories.

After analyzing the results of the zoom sample, it was found that no significant differences existed between these results and those of the corresponding sub-sectors taken from the general sample; this reinforces and validates the study presented here. Since they provide no new information from the statistical point of view, and in the interests of concision, the zoom results are not included in this document.

2.2.2 Questionnaire

The questionnaire employed was designed in accordance with the specific objectives of the survey; in order to facilitate its application, questions were arranged in six main groups:

1. Identification and characterization of company and interlocutor.
2. Knowledge and use, both internal and external, of computer-assisted design (CAD) and of numerical simulation (CAE). Training needs in this area.
3. Knowledge and use, both internal and external, of statistical techniques and Operations Research (ST/OR). Training needs in this area.
4. Knowledge and use, both internal and external, of other mathematical techniques (OMT) applicable to industry.
5. Human resources in mathematical techniques.
6. Collaboration with Universities and consultancy requirement.

The questionnaire and the main results are shown in Section 3. Details of the questionnaire can also be found at the following website: http://www.i-math.org/mapa_demanda as well as in a separate document entitled *Informe Técnico del Mapa TransMATH Demanda* (TransMATH Demand Map Technical Report).

In order to facilitate data processing and statistical analysis, the databases from the survey were transferred and integrated into the "Statistical Product and Service Solutions" (SPSS) statistical package.

3 MAIN RESULTS

The general results of the survey are detailed below, taking as reference the questionnaire employed in the survey itself. As previously explained in Section 2.2.3, the questionnaire is arranged in various blocks, beginning with the characterization of company and interlocutor, which is followed by a series of questions concerning the mathematical techniques employed by the companies, specifically the techniques outlined below:

- Computer-assisted design (CAD),
- Numerical simulation / Computer-assisted engineering (CAE),
- Statistics and Operations Research (ST/OR),
- Other mathematical techniques (OMT)

Finally, interviewees were asked about human resources in mathematical techniques, collaboration with Universities or Research Centers, and consultancy requirements.

A summary of the percentage of affirmative replies - in relation to the sample total – to each of the questions in the questionnaire is shown below.

C1. Can you tell me what your position in the company is?

Responsible for research, development, innovation or engineering	2%
Responsible for methods, schedules, organization or technical department	2%
Responsible for quality	3%
Responsible for informatics	33%
Director/manager	20%
Other (responsible for administration, administrative post, etc)	41%

C2. Does your company have any of the following departments?

Quality control	52%
Design, technical department	32%
R+D+i, development of new products products	20%

C3. (If you have R+D+i or development) Is either of these departments in Spain, abroad or both?

83% (Spain)	6% (Abroad)	10% (Both)

>> CAD/CAE

C4. Whether internally within the company or externally through outsourcing or collaboration, does you company use CAD? In other words, does it use computer-assisted design in, for example, part design, plans or blueprints, images or graphs?

66% (No)	34% (Yes)

C5. Whether internally within the company or externally, does your company use computer calculation programs to simulate, predict or study the behaviour of products or processes? For example, for thermal studies, mechanical forces, manufacturing processes, etc.. This is also sometimes known as computer-assisted engineering, or CAE for short. So does your company use CAE?

87% (No)	13% (Yes)

C6. (If you use CAE) Is CAE conducted internally within the company, or externally outside the company or both?

63% (Internal)	16% (External)	22% (Both)

C7. (If you use CAE) For what type of phenomena do you use CAE?

Mechanical or Structural	50%
Thermal or Thermal Dynamics	20%
Manufacturing processes: injection, printing, embossing, forging, etc..	39%
Electronics and/or Electromagnetics	15%
Fluids: gases, liquids	11%
Acoustics or vibroacoustics	7%
Environmental	15%
Others, such as multi-physics	7%

C8. (If you perform CAE internally or both) Is CAE used internally with commercial programs, free software or both?

56% (Commercial Progs.)	16% (Free Software)	27% (Both)

C9. (If you use CAE internally or both) Do you have customized CAE programs or modules for the company?

46% (No)	46% (Yes)	8% (Dk)

C10. (If you use CAD) Are the results obtained with CAD used later in CAE applications, either within the company or externally? (The answer is No if they only do CAD design and do not use it later to "simulate, predict or study the behavior of products or processes).

66% (No)	26% (Yes)	8% (Dk)

C11. Does your company have any need in relation to CAD or CAE, for example, help and advice about its applicability; training; implantation, development or improvement of programs?

97% (No)	3% (Yes)

C12. (If you have any requirement) What type of need with CAD/CAE do you have?

Information or advice about application of CAD/CAE in the company	61%
Selection, initial implantation and validation of CAD/CAE tools	20%
CAD/CAE training	51%
Definition or calculation of processes in CAD/CAE	13%
Customized development of CAD/CAE software or interfaces CAD/CAE	18%
Integrating CAD with CAE or both with company processes	13%
Other different	10%

>>STATISTICAL TECHNIQUES AND DATA ANALYSIS SUPPORT FOR DECISION-MAKING

C13. Whether internally or externally, do you use statistical techniques, data analysis techniques, or support for decision-making; for example, for analysis of clients, markets, products, quality, planning, risk, logistics, assignation and optimization of resources and processes?

51% (No)	49% (Yes)

C14. (If you use ST/OR) Is this use internal within the company, external or both?

79% (Internal)	5% (External)	15% (Both)

C15. (If you use ST/OR) in what type of areas do you use statistical, data analysis or support techniques for decision-making?

Quality control	48%
Control and optimization of stocks	30%
Control and optimization of production processes	34%
Risk of financial product analysis	28%
Strategy, decision, logistics and planning	43%
Client analysis and market or product studies	66%
Exploitation of internal information (data mining, business intelligence)	17%
Others; e.g. experimental design, clinical analysis, etc..	2%

C16. (If you use ST/OR internally or both) Are the programs you use internally for these subjects commercial, with free software or both?

49% (Commercial Progs.)	20% (Free Software)	25% (Both)

C17. (If you use ST/OR internally or both) Do you have customized programs or modules for these subjects in your company?

26% (No)	71% (Yes)	3% (Dk)

C18. Does your company have any needs in statistics, data analysis, or in support for decision-making?

93% (No)	7% (Yes)

C19. (If you have any requirements) What are these needs?

Training	39%
Quality control	30%
Control and optimization of stocks	23%
Control and optimization of production processes	25%
Risk and financial product analysis	23%
Strategy, decision-making, logistics, planning	36%
Client analysis and market or product studies	40%
Exploitation of internal information (data mining, business intelligence)	15%
Others; e.g. experimental design, clinical analysis, etc..	2%

>>OTHER MATHEMATICAL TECHNIQUES (OMT)

C20. Whether internally or externally, do you apply other mathematical techniques different from those mentioned above in areas such as: geographical location, image or signal treatment; geometry, design or visualization; bio-informatics or bio-mathematics; search and codification of information, or computation? (*)

92% (No)	8% (Yes)

C21. (If you use OMT) Is their use internal, external or both?

73 % (Internal)	7% (External)	20% (Both)

C22. (If you use OMT) In what applications do you use these other mathematical techniques below? (different from those already indicated: CAD, CAE, statistics, data analysis, decision-making support)

Digital images: graphs, video, animation, image recognition	48%
Geometric analysis: computational geometry, visualization, CAD development, symbolic methods	24%
Digital treatment of signals	14%
Design of geographical location systems such as GIS or GPS	39%
Communication networks	25%
Codification of information, cryptography, computer security	18%
Computation, computational algebra, language processors, symbolic-numerical algorithms	9%
Search and treatment of information and knowledge: semantic web, algorithms for the Internet	13%

Bioinformatics, genomics and proteomics	3%
Biomathematics: applications in life and health sciences (such as diagnostic techniques, medical prescriptions, administration of drugs, growth and propagation of disease, pest control, systems biology)	3%
Others	2%

>> GENERAL ASPECTS

C23. Score from 0 to 10 what knowledge your company has about the possible applications of the techniques mentioned: CAD, CAE, statistics, etc.. Zero (0) is the lowest score; 10 is the highest, and 5 average.

Mean: 4.4

C24. Is your company prepared to collaborate with Universities in end-of-course final projects, master courses or in carrying out work practice programs in the area of the techniques mentioned?

44% (No)	32% (Yes)	24% (Dk)

C25. In the short or medium term, do you think that your company will require mathematical services or personnel qualified in Mathematics or Statistics in order to apply any of the techniques mentioned?

86% (No)	5% (Yes)	9% (Dk)

>>HUMAN RESOURCES IN MATHEMATICAL TECHNIQUES

C26. Do you have any personnel qualified in Mathematics or Statistics on your workforce?

85% (No)	8% (Yes)	7% (Dk)

C27. In what areas of work are they engaged?

Coputer management or systems	48%
CAD/CAE	15%
Statistics, data analysis, decision-making support	49%
Other mathematical techniques	15%
Other tasks	29%

>> COLLABORATION AND CONTRACTS WITH UNIVERSITIES AND RESEARCH CENTERS

C28. Over the last 5 years, and in any field including those unconnected with mathematics, has your company collaborated or outsourced with Universities or research centers, training projects, research projects or technological services (not necessarily mathematical)?

61% (No)	31% (Yes)	8% (Dk)

C29. (In the affirmative case above) In what subjects did you outsource or collaborate? In training; in research areas or technological services or in both?

61% (Training)	19% (Research or technological services)	17% (Both)

C30. (If you did outsource or collaborate) Score from 0 to 10 your satisfaction with this collaboration or outsourcing. (Zero (0) is the lowest score; 10 is the highest and 5 is average)

Mean: 7.4

>>OTHERS

C31. (If you have requirements in CAD/CAE, statistics, etc, or apply other mathematical techniques) Would you be prepared for our technical experts from the i-Math Project to contact you, without obligation, to advise you about any of the subjects dealt with in the survey?

66% (No)	34% (Yes)

II RESULTS OF THE STUDY

In this section, the statistical analysis carried out with the data obtained from the survey is presented. Since the choice of the sample was based on three criteria – company size, sector and Autonomous Community – and for the first two a sample proportional to the current population was not considered, it was decided that a descriptive statistical treatment should be given to the sample data. Details of the results obtained according to each of the above-mentioned criteria now follow.

4 CHARACTERIZATION OF COMPANIES

This block includes an analysis of the distribution of the population and of the sample according to Autonomous Community, sector and company size. In addition, the percentage of companies belonging to the sample with departments of *Quality Control, Design, technical department, R+D+i or new product development* is shown; the latter is analyzed according to whether it is located in Spain or abroad. Finally, given the specific nature of the questionnaire, an analysis of the interlocutors who have responded to the survey is also made.

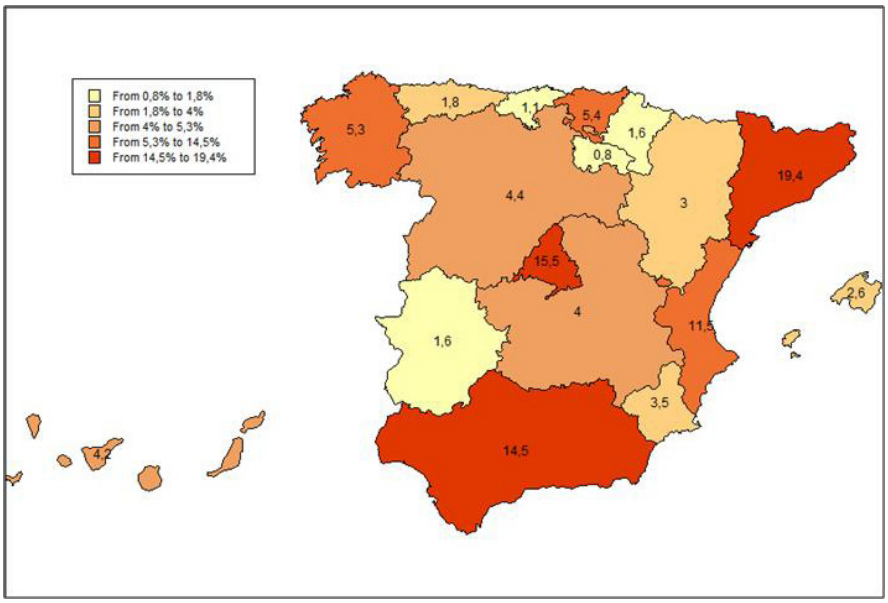
4.1 Distribution of the companies by Autonomous Community, sector and size

By Autonomous Community

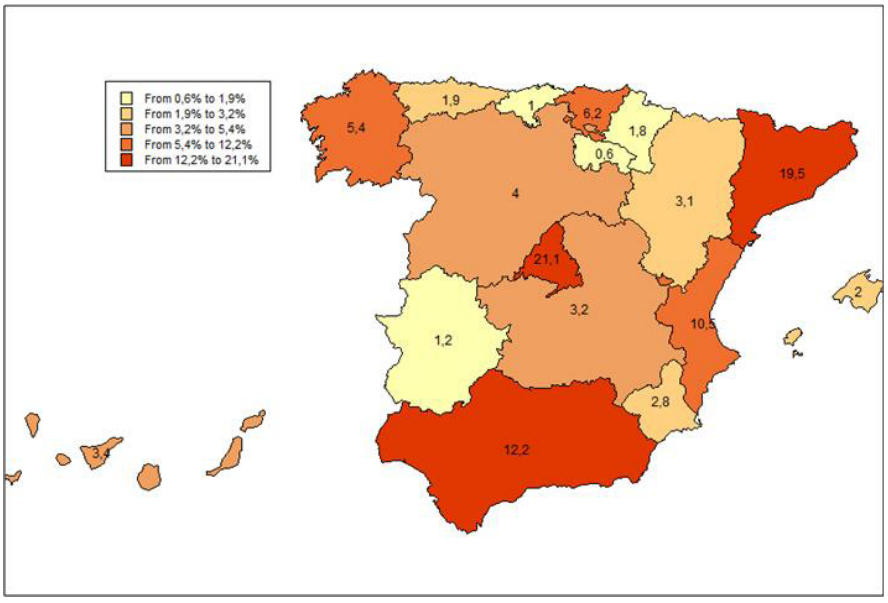
The group of companies for this study is composed of those located in Spain with 10 more employees; the Autonomous Cities of Ceuta and Melilla are not included. The distribution maps of population and of the general sample of companies selected for this study are shown below; in particular, the percentage of companies for each Autonomous Community calculated in relation to the total number of companies in Spain is shown in Map 4-1; the percentage of sample companies in each community in relation to the total of companies consulted in Spain is shown in Map 4-2.
The population data is taken from the *Directorio Central de Empresas* (DIRCE) of the *Instituto Nacional de Estadística* (INE). The companies are spread over thirteen sectors of activity and amount to a total of 195,098 firms.

As regards the data in Map 4-1 showing the population distribution according to different autonomous communities, one may see that Cataluña is the community with the largest number of companies with 19.42% of the total, followed by Madrid with 15.48%, Andalucía with 14.51% and the community of Valencia with 11.51%. These four communities together account for 60% of all the companies currently active in Spain in the CNAE divisions considered in the study. Some way behind comes the Basque Country with 5.37%, followed by Galicia, which occupies sixth place with 5.2% of the total of all companies.

As regards the sample, the distribution of data presents a similar picture, with the exception of the communities of Madrid and Cataluña, which here swap positions, with Madrid occupying first place in the number of companies sampled – 21.11%. This is due to the process followed in the design of the sample, since while affixation by autonomous community was proportional, the size of each stratum was fixed non-proportionally beforehand according to the number of employees and sector of activity. The effect of applying this criterion can be seen in Figure 4-1, where population percentage is compared against the sample percentage in each autonomous community.



Map 4-1: Distribution of company population by Autonomous Community.



Map 4-2 : Distribution of company sample by Autonomous Community.

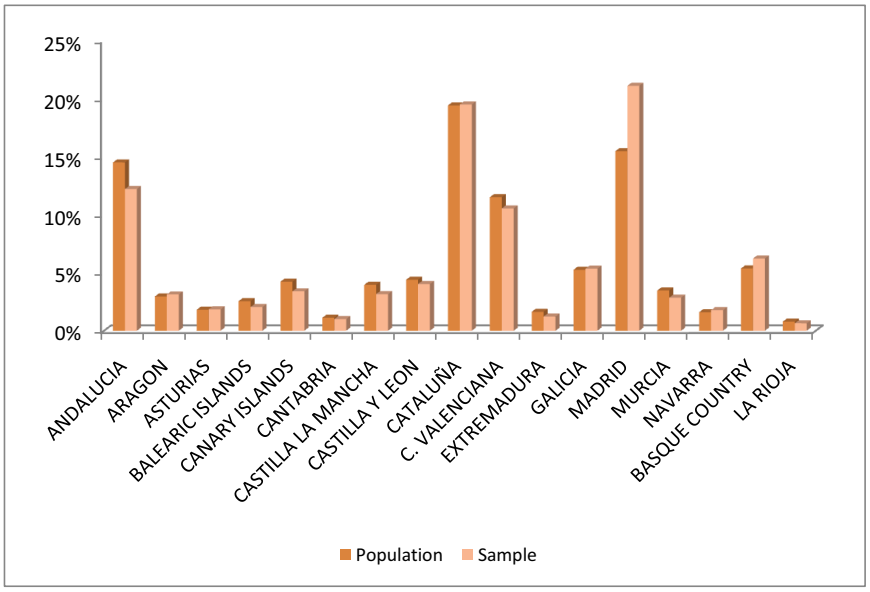


Figure 4-1: Distribution of population (N= 195,098) and sample (n=6,716) by Autonomous Community.

By Sector

Recall that in order for the selection of the 13 sectors to be representative of the population, consideration was given to those in which the use of mathematical techniques evaluated in the study was the most relevant and of greatest applicability. Those sectors associated with financial services, engineering, architecture and R+D are of particular interest.

Once the sampling frame was decided, those sectors whose activity was most closely related with the transfer of mathematical technology were identified. These are as follows: *Energy, chemical and environment, Transport and storage, Finance, Health and technical services.* In obtaining the sample, with the aim of avoiding over representation of those sectors with many companies and with *a priori* minor interest in the study, such as *Commerce*, with 36,708 companies, the criterion adopted was non-proportional (see Figure 4-2).

In Figure 4-2 one may see that the sectors with the largest number of companies in the population belong to the *Construction, Commerce and Miscellaneous services* categories. It is necessary to take into account that approximately 85% of companies in Spain are small (up to 49 employees) and most of them belong to the above-mentioned sectors. If population is compared with the sample chosen (see Figure 4-2), one observes that the distribution of companies by sector is smoothed in the sample. As previously explained, this is due to the criteria chosen in the design phase. Of all the

companies represented in the sample, only 47% belong to the small company category.

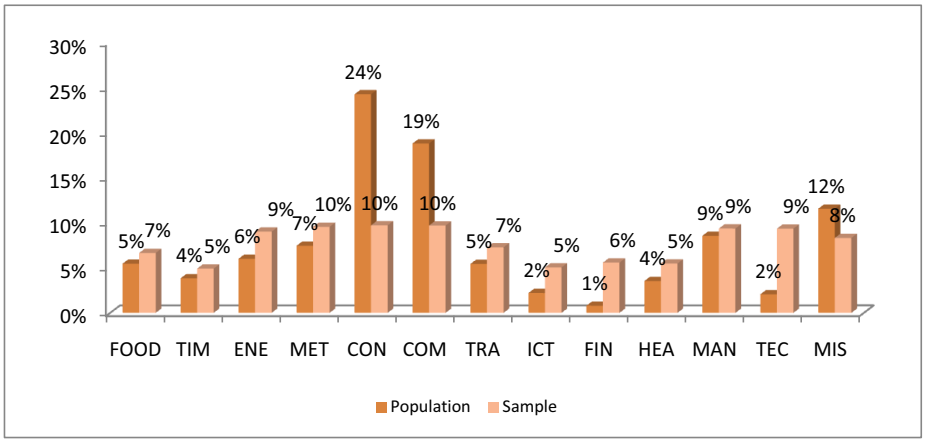


Figure 4-2 : Distribution of population and sample by sector. The sector codes can be seen in Table 2-4 (N= 195,098) and sample (n=6,716).

By company size

With the aim of avoiding an excessive accumulation of surveys among small companies, and also to provide an adequate representation of large and medium-sized companies, on taking the sample it was decided not to follow a criterion proportional to the size of the population. It is for that reason that the distributions of population and the sample exhibit such differences. See Figure 4-3 and Figure 4-4.

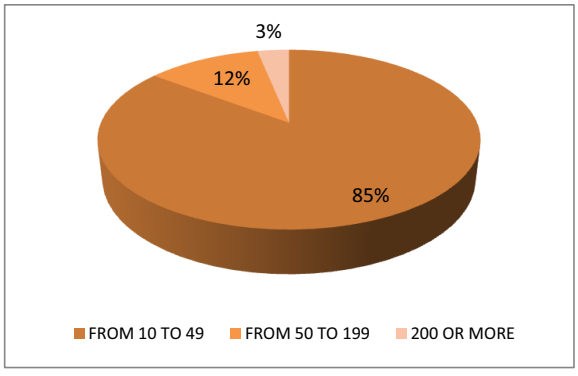


Figure 4-3: Distribution of the population according to company size (N= 195,098).

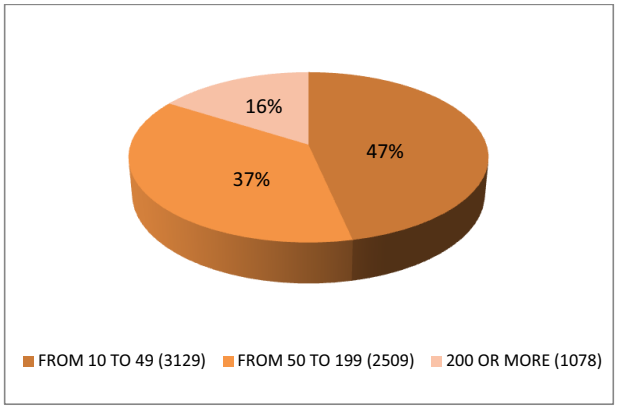


Figure 4-4: Distribution of the sample according to company size (n=6,716).

If a segmented study is made of the population by sector and one sees in each sector the distribution of companies according to their size, no appreciable differences can be seen, the percentage of small companies in each sector being much greater than the rest. The sectors in which this proportion decreases, thereby increasing the number of large and medium-size companies, are as follows: *Finance; Health; and Information and communication technology (ICT).* See Figure 4-5.

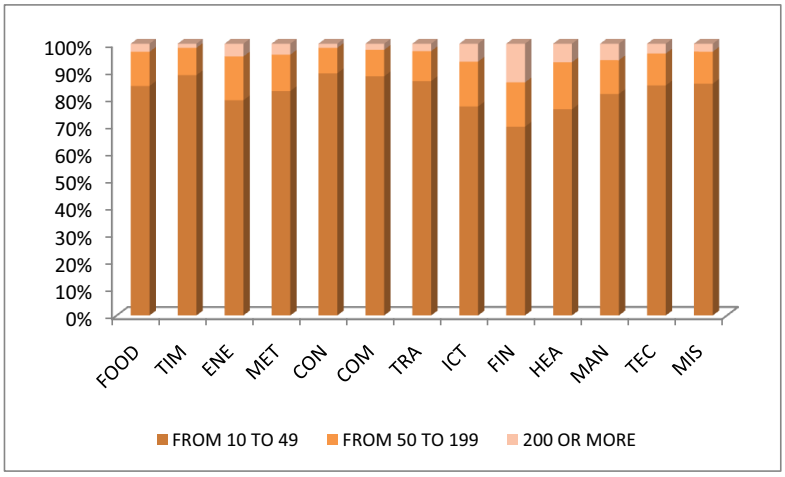


Figure 4-5: Population distribution of company size by sector.

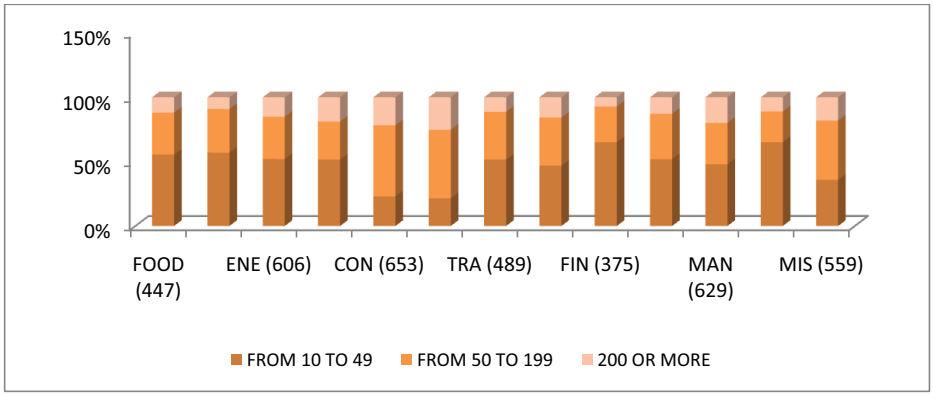


Figure 4-6: Sample distribution of company size by sector.

If we now analyze the sample (Figure 4-6), the distribution changes notably, since one of the priorities of this study was to take a sample that gave a good representation of medium-sized and large companies. Thus, the proportion of medium-sized and large companies increases in each of the sectors, a feature of great interest in this study and one which enabled more attention to be given to those areas where mathematics should without doubt should play a more relevant role.

4.2 Analysis of interlocutors

In order to analyze the influence that the interlocutor profile may have on the results of the survey, the interviewees were asked about their position within the company. These positions are categorized as follows:

- *Responsible for research, development, innovation or engineering.*
- *Responsible for methods, schedules, organization or technical department.*
- *Responsible for quality.*
- *Responsible for computers.*
- *Director/manager.*
- *Other (responsible for administration, administrative post, etc.).*

20% of interviewees stated that they held managerial posts, while 33% said they were responsible for computers and IT, both groups comprising a little over half of the persons interviewed. Among the remaining 50%, most were involved in administrative tasks (41%), while approximately only 7% of those surveyed had any responsibility for research, innovation, methods, quality, etc.. The distribution of interlocutors is shown in Figure 4-11 and Table 4-1.

By sector

No substantial changes are observed in the division by sector; it is worth mentioning the construction sector, where 57% of those interviewed responded to the *Others* section, and also the *Technical services* (12%), *Metallurgy and machinery (11%) and Information and communication technology (8%)* sectors, which provided the largest number of interviewees with posts responsible for *Research, development, innovation or engineering, methods, schedules, organization and technical department or Quality* in their respective companies. See Figure 4-7 and Table 4-1.

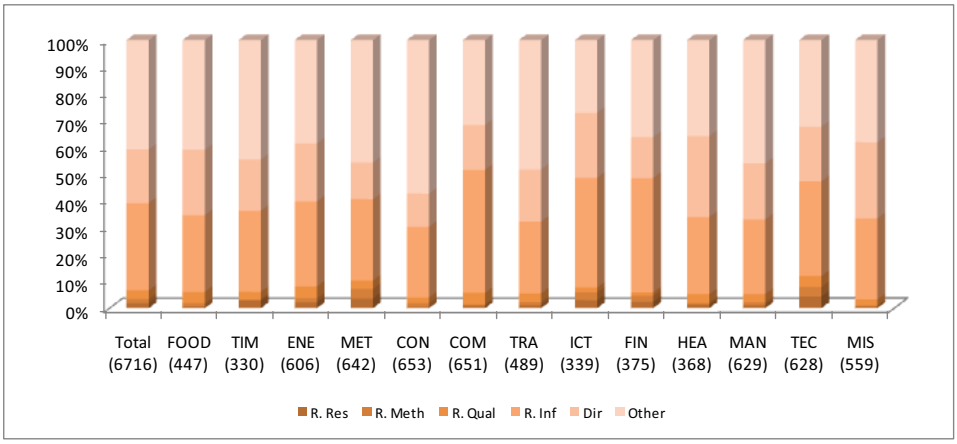


Figure 4-7: Interviewees' posts by sector.

Sector	Research	Meth	Quality	Comp/IT	Dir.	Other
FOOD	1%	1%	4%	29%	24%	41%
TIM	3%	1%	3%	30%	19%	45%
ENE	2%	1%	4%	32%	22%	39%
MET	4%	4%	3%	30%	14%	46%
CON	0%	1%	2%	26%	12%	57%
COM	1%	0%	4%	46%	17%	32%
TRA	1%	1%	3%	27%	19%	48%
ICT	3%	3%	2%	41%	24%	27%
FIN	2%	2%	1%	43%	15%	36%
HEA	1%	1%	3%	29%	30%	36%
MAN	1%	1%	3%	28%	21%	46%
TEC	4%	4%	4%	35%	20%	32%
MIS	1%	0%	2%	30%	28%	38%
Total	**2%**	**2%**	**3%**	**33%**	**20%**	**41%**

Table 4-1: Interviewees' posts by sector.

By company size

In those companies employing most people, 59% stated in the questionnaire that they held posts responsible for computers and IT and 21% responded to the profile *Other*, thus accounting for 80% of all the interlocutors belonging to this group (see Figure 4-10). In the medium-size companies, the largest percentages corresponded to the same two interlocutor profiles, which together account for 38% (see Figure 4-9), while in the small companies the largest percentages belong to the profile *Other* (50%), and 25% in the Director/Manager profile (see Figure 4-8). However, there is no appreciable difference between the three groups of companies if one analyzes the percentage of interlocutors holding positions responsible for *Research, development, innovation or engineering, Methods, schedules, organization and technical department or Quality* in their respective companies (see Table 4-2). Figure 4-11 shows a comparison of posts held by interlocutors surveyed for each group of companies in terms of the overall sample.

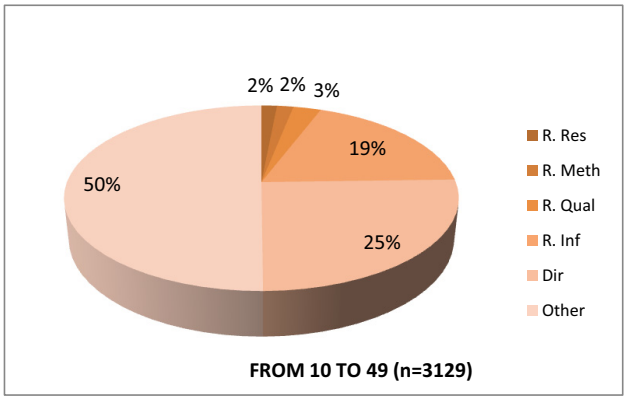


Figure 4-8: Interviewees' posts in small companies.

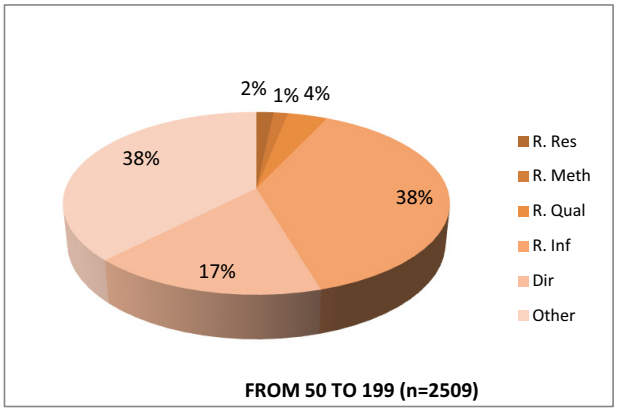


Figure 4-9: Interviewees' posts in medium-size companies.

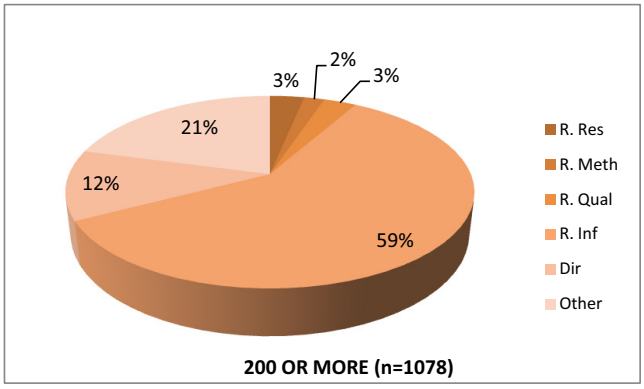


Figure 4-10: Interviewees' posts in large companies.

Position	From 10 to 49	From 50 to 199	200 OR MORE
Research	2%	2%	3%
Methods	2%	1%	2%
Quality	3%	4%	3%
Computer/IT	19%	38%	59%
Director/Manager	25%	17%	12%
Other	50%	38%	21%
Total	100%	100%	100%

Table 4-2: Interviewees' posts by company size.

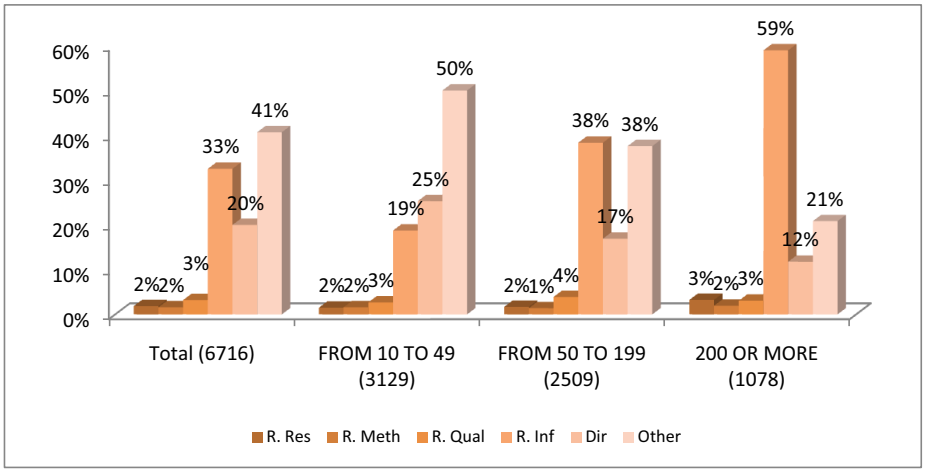


Figure 4-11: Comparison of interviewees' posts in the sample by company size.

By companies with an R+D+i department

Given the nature of this study, companies with an R+D+i department are of particular interest (Figure 4-16). A detailed analysis of the interlocutors belonging to a sample taken solely of those companies with an R+D+i department is given below, and contains data referring to a base of 1,349 companies, which correspond to 20% of all the companies included in the survey.

Figure 4-12 shows the position held by the interviewee in the respective company; one may observe that, although these companies may have a department specializing in research, most of the people who responded to the survey belong to the *Remaining interlocutors* category (89%). Only 5% of the people interviewed in this category stated that they held a position as *Responsible for research, development, innovation or engineering.* This fact reveals the difficulty of reaching the ideal interlocutor in such specific studies as that presented here; it is therefore noteworthy that, on narrowing the sample down to companies with an *R+D+i* or *new product development* department, the percentage of interlocutors with posts responsible for *Research, development, innovation or engineering, Methods, schedules, organization and technical department* or *Quality* should amount to 10%, only three percent higher than the sample total.

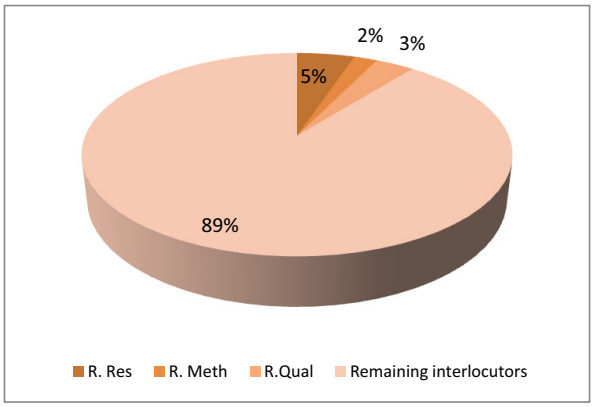


Figure 4-12: Interviewees' posts in companies with an R+D+i department (n=1,349).

If segmentation is performed by sector, the highest percentages of interlocutors belonging to the category *Responsible for research, development, innovation and engineering* are involved in activities relating to *Timber and paper,* and *Technical services,* with 8% of interlocutors having this type of profile. It is also worth pointing out the 9% with *Responsible for Quality* in the *Transport and storage* sector.

Figure 4-13 reflects the number of surveys yielding responses for those responsible for *Research, development, innovation or engineering, Methods, schedules, organization and technical department* or *Quality,* taking those companies sampled with an R+D+i department as the base. The data is compared against the total of the sample and according to each sector.

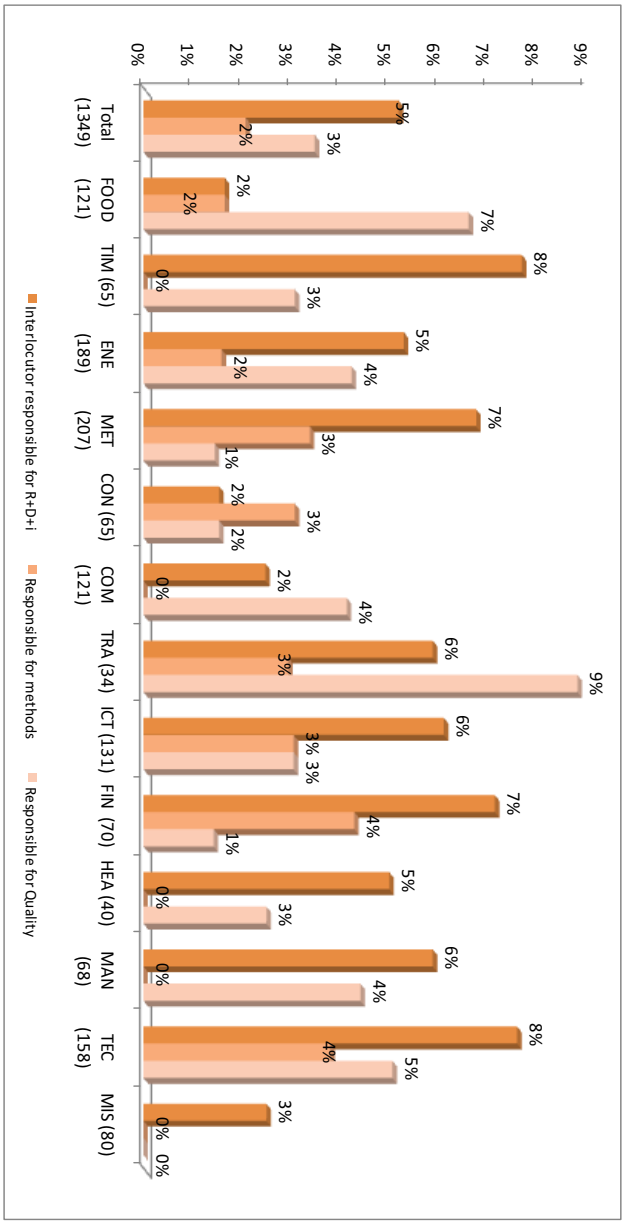


Figure 4-13: Interviewees' posts in companies with an R+D+i against the sample total and by sector.

4.3 Departments

In order to perform and analysis of the types of departments in a company, question C2 in the questionnaire referred to whether the company had any of the following departments:

- *Quality control.*
- *Design, technical department.*
- *R+D+i, new product development.*

Of the total sample, 38% of companies did not have any of these departments, while 52% had a *Quality Control* department, 32% a *Design or technical department* and 20% an *R+D+I or new product development* department. See Table 4-3 and Figure 4-15

By sector

In the division of the sample by sector, more than 65% of companies whose activities involved the *Food and clothing, Energy, chemical, environment, Metal and machinery* sectors had a *Quality Control* department. In this latter sector, 60% of the companies had a *Design or technical department,* which is the highest value in relation to the other sectors (see Table 4-3). As regards the *R+D+i or new product development* departments, the most noteworthy are the *information Technology and Communication* (39%), *Metal and machinery* (32%), *Energy, chemical and environment* (31%) departments. The lowest percentage corresponds to the *Transport and storage* sector, where only 7% of companies had this department (see Figure 4-14).

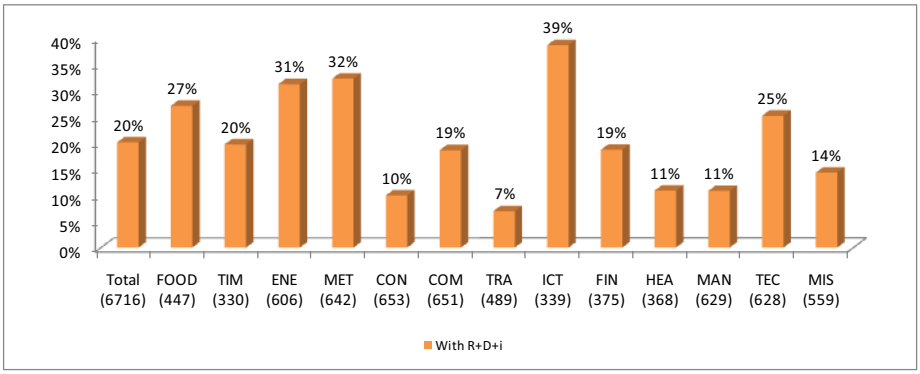


Figure 4-14: Companies with an *R+D+i* or *new product development* department against the total sample and by sector.

Sector	Quality	Design, Tech. Dept.	R+D+i or development	None
FOOD (n=447)	67%	28%	27%	29%
TIM (n=330)	48%	49%	20%	36%
ENE (n=606)	68%	42%	31%	26%
MET (n=642)	67%	60%	32%	23%
CON (n=653)	46%	39%	10%	42%
COM (n=651)	55%	27%	19%	37%
TRA (n=489)	49%	11%	7%	49%
ICT (n=339)	40%	44%	39%	29%
FIN (n=375)	29%	19%	19%	59%
HEA (n=368)	52%	14%	11%	45%
MAN (n=629)	41%	19%	11%	52%
TEC (n=628)	52%	46%	25%	28%
MIS (n=559)	46%	14%	14%	47%
Total (n=6.716)	**52%**	**32%**	**20%**	**38%**

Table 4-3: Type of department against sample total and by sector.

By company size

As regards company size, one observes that more than half of medium-sized companies in the sample and 73% of large companies possess a *Quality Control* Department. Both the *Design* and *Technical* and the *R+D+i* or *new product development* departments yield lower percentages in the three groups. In general, as company size increases the number of companies having departments of any of the types mentioned in the previous paragraph also increases. This relation is inverted when we analyze by size those companies that have none of these departments, the smallest companies yielding the highest proportion with 48%. As company size increases, this percentage decreases, falling to 20% for those large companies that have none of the said departments (see Figure 4-15).

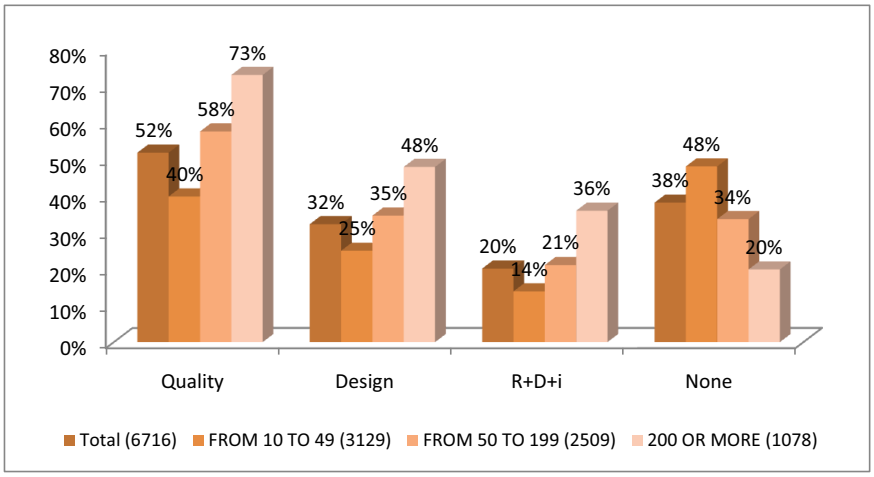


Figure 4-15: Type of department against the sample total and by company size.

4.3.1 Companies with R+D+i or new product development departments

By companies with R+D+i or new product development departments

As mentioned above, of all the different types of departments, those of particular interest in this study are the *R+D+i* or *new product development* departments, which account for 20% of all the companies in the sample. See Figure 4-16.

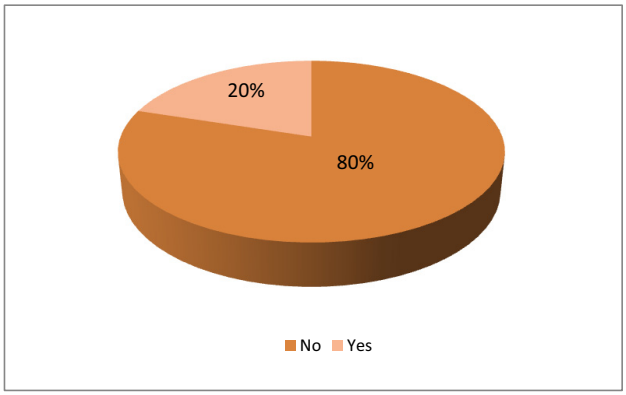


Figure 4-16: Companies in the survey with R+D+i or new product development departments (n=6,716).

Of the 6,716 companies consulted in the sample, 1,349 possess *R+D+i* or *new product development* department. These 1,349 companies are employed as the basis for the analysis in the following sections.

Figure 4-17 shows the distribution by sector of those companies having an *R+D+i* or *new product development* department. The graph reveals that 15% are related with activities in the *Metal and machinery* sector, 14% with *Energy, chemical* and *environment*, 12% with *Technical services* and 10% with *Information Technology and Communication*, these sectors together amounting to 51% of all the companies in the sample with an R+D+i department.

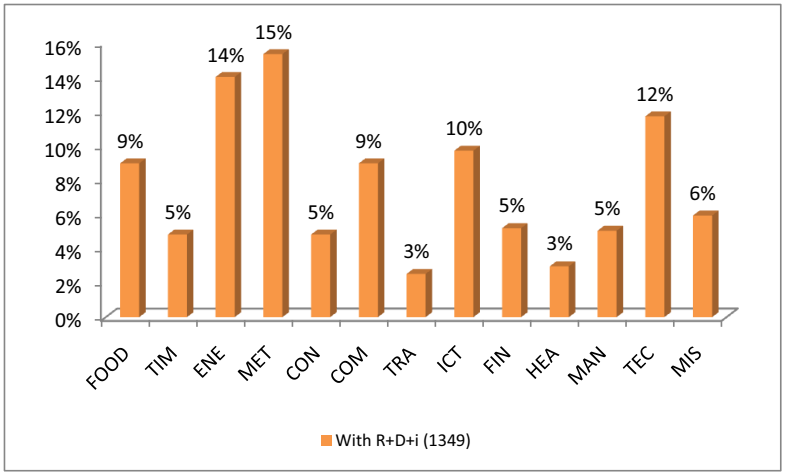


Figure 4-17: Distribution of the number of companies in the sample with an R+D+i or new product development department, by sector.

4.3.2 Analysis of the geographical location of the R+D+i or new product development department

Attention has also been given to the location of these departments, with classification according to whether they are found only in *Spain*, only *Abroad* or *Both* at the same time. Figure 4-18 shows that in 83% of cases the department was in *Spain*, while only 6% of those companies taking part in the survey stated that this department was located *Abroad* and 10% said they had such departments in *Both* locations at the same time. In the analysis by sector, it is worth pointing out that 39% of companies involved in *Miscellaneous services* had an *R+D+i* or *new product development* department *Abroad*, while 6% stated that such departments were located both in *Spain* and *Abroad*, yielding as a result in this sector that 45% of the 80 companies with an R+D+i department, that is, 36 companies, have all or part of these departments located abroad. See Table 4-4.

Note that the sum of *Spain, Abroad* or *Both* does not always correspond to the total number of companies with an *R+D+i* department, which is due to the fact that some companies did not reply to this question.

Sector	Spain	Abroad	Both	Have R+D+i	Total companies
FOOD	110	1	9	121	447
TIM	58	2	3	65	330
ENE	147	7	33	189	606
MET	176	8	21	207	642
CON	59	1	5	65	653
COM	84	16	18	121	651
TRA	28	1	5	34	489
ICT	121	5	4	131	339
FIN	52	6	11	70	375
HEA	38		1	40	368
MAN	57	3	8	68	629
TEC	141	5	12	158	628
MIS	43	31	5	80	559
Total	**1,114**	**86**	**135**	**1,349**	**6,716**

Table 4-4: Number of companies in the sample having an R+D+i or new product development department with location by sector.

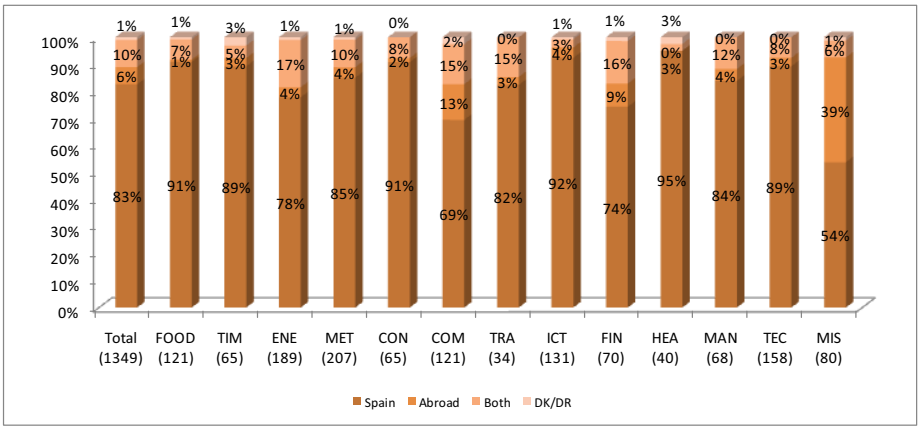


Figure 4-18: Location of R+D+i department against sample total by sector.

If the sample is divided by company size, as the number of employees in each company increases, the percentage of companies stating that they have an *R+D+i* or *new product development* department either in *Spain* or *Abroad* also increases, ranging from 4% in small companies to 16% in the largest. As regards those departments located only Abroad, no significant differences are observed (see Figure 4-19).

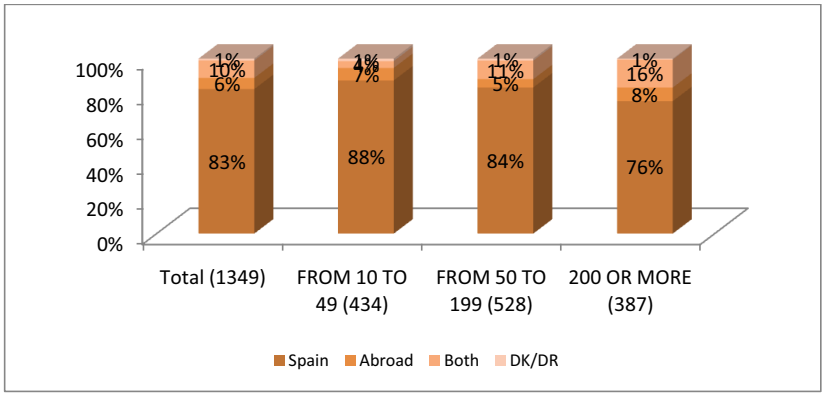


Figure 4-19: Location of R+D+i departments against sample total and by company size.

5 CAD/CAE TECHNIQUES

5.1 Use of CAD/CAE

5.1.1 Use of CAD techniques

This section is devoted to analyzing whether CAD is used either internally within the company or externally through collaboration or outsourcing, CAD being understood as Computer-Assisted Design for the design of parts, plans, images or graphs. According to the data gathered in this survey, 34% of companies in the sample do indeed use CAD.

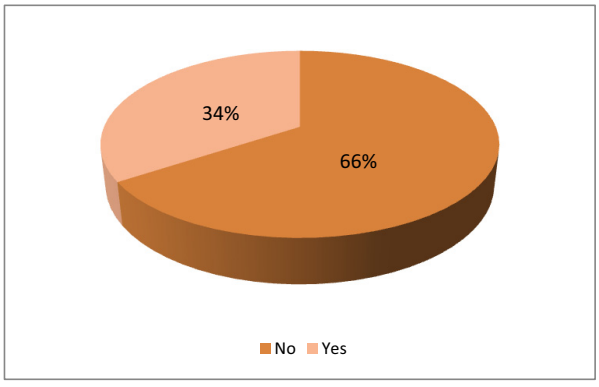
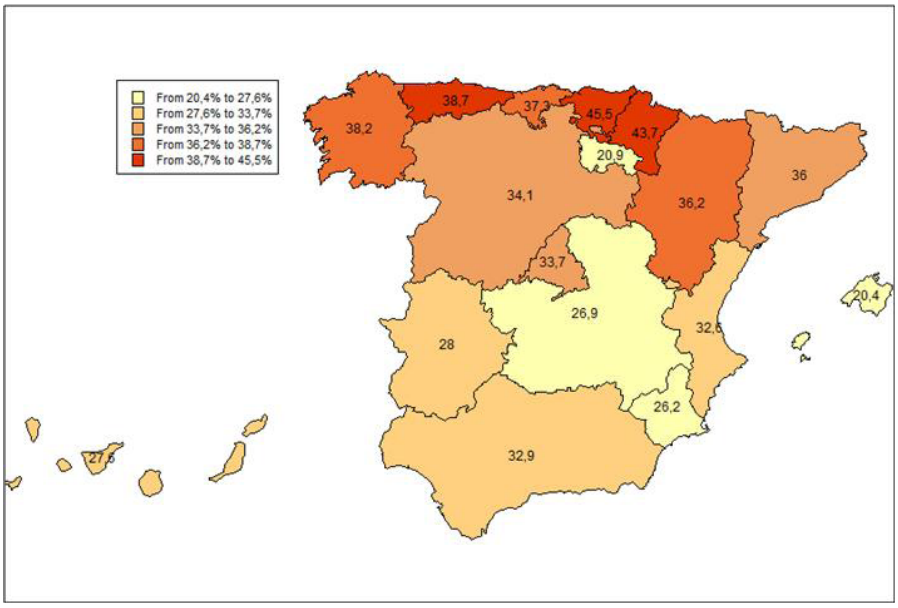


Figure 5-1: Use of CAD in the sample (n=6,716).

By Autonomous Community

If the results are broken down by Autonomous Community, one observes that Aragón, Asturias, Cantabria, Cataluña, Galicia, Navarra and the Basque Country exceed the mean within a range that varies between 45% of companies in the Basque Country and 36% in Aragón and Cataluña. The companies in which CAD is least used in their processes belong to the communities of La Rioja and the Balearic Islands, with approximately 20%. See Map 5-1 and Table 5-1.



Map 5-1: Companies that use CAD by Autonomous Community (n=6,716).

AUTON. COM.	Do not use CAD	Use CAD	Total companies by A.C.
ANDALUCIA	550	270	820
ARAGON	134	76	210
ASTURIAS	76	48	124
BALEARIC ISLANDS	109	28	137
CANARY ISLANDS	165	63	228
CANTABRIA	42	25	67
CASTILLA LA MANCHA	155	57	212
CASTILLA Y LEON	178	92	270
CATALUÑA	838	472	1,310
C. VALENCIANA	477	231	708
EXTREMADURA	59	23	82
GALICIA	222	137	359
MADRID	940	478	1,418
MURCIA	141	50	191
NAVARRA	67	52	119
BASQUE COUNTRY	228	190	418
LA RIOJA	34	9	43
Total	**4,415**	**2,301**	**6,716**

Table 5-1: Companies that use CAD by Autonomous Community.

By sector

If the sample is segmented by sector, one observes that the percentage of companies that use CAD increases considerably against the total sample in the *Metal and machinery*, *Technical services* and *Construction* sectors, with a figure of more than 50%. Next come the *Energy*, *chemical and environment*, and *Timber and paper* sectors, giving slightly lower values but still above the mean, with approximately 45% of companies. See Figure 5-2.

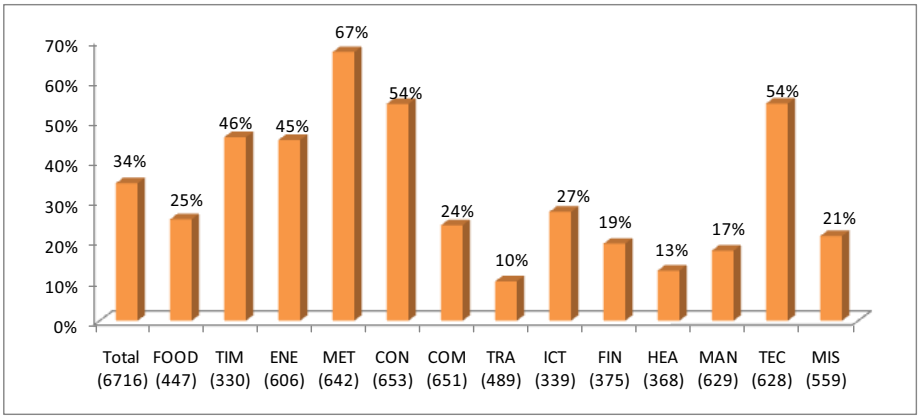


Figure 5-2: Use of CAD against the sample total and by sector.

Of those companies that use CAD, almost 50% are engaged in activities relating to *Metal and machinery*, *Construction* and *Technical Services*. See Figure 5-3.

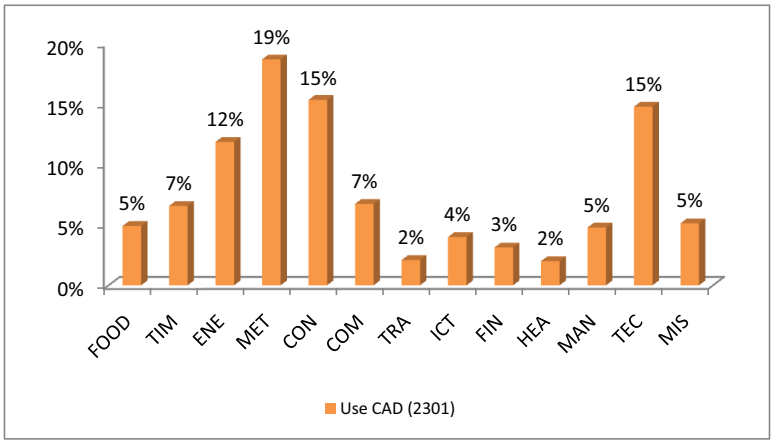


Figure 5-3: Distribution of companies using CAD by sector.

By company size

If the sample is divided into three groups, the use of CAD techniques according to company size increases considerably in medium-size and large companies, which was expected, going from 29% in companies with fewest employees to 49% in the largest companies. See Figure 5-4.

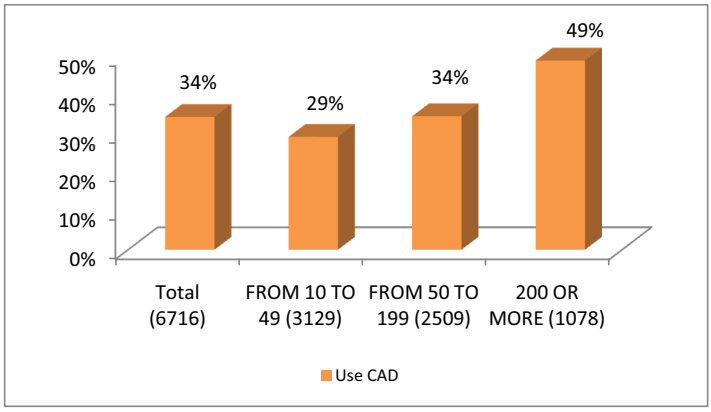


Figure 5-4: Use of CAD as compared with sample total and by company size.

Once again by taking only those companies that use CAD, which amount to 2,301, 23% of these are large companies as against almost 40% which are either small or medium-sized. It should not be deduced from this that the small and medium-sized companies

are those that make most use of CAD techniques, since it should not be forgotten that 84% of the firms taking part in the survey belong precisely to the small and medium-sized category, with only 16% corresponding to companies with a workforce greater than 200.

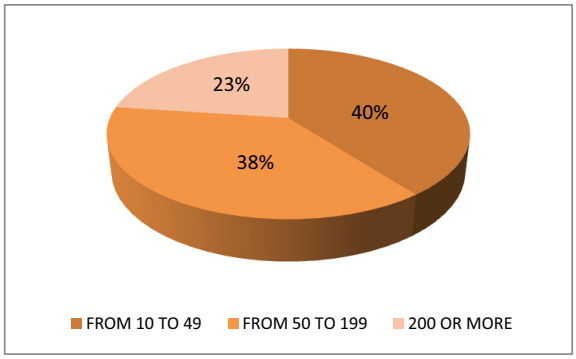


Figure 5-5: Distribution of companies using CAD by company size (n=2,301).

5.1.2 Use of CAE techniques

Question C5 concerned whether or not companies used computer calculation programs to simulate, predict or study the behavior of products and/or processes; for example, for thermal studies, mechanical forces, manufacturing processes, etc.; what is often known as Computer-Assisted Engineering or CAE for short. After analysis of the survey, on the basis of the sampled data it was calculated that approximately 13% of companies make use of CAE techniques. See Figure 5-6.

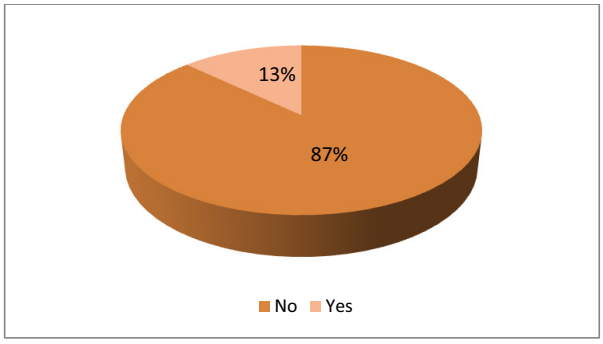
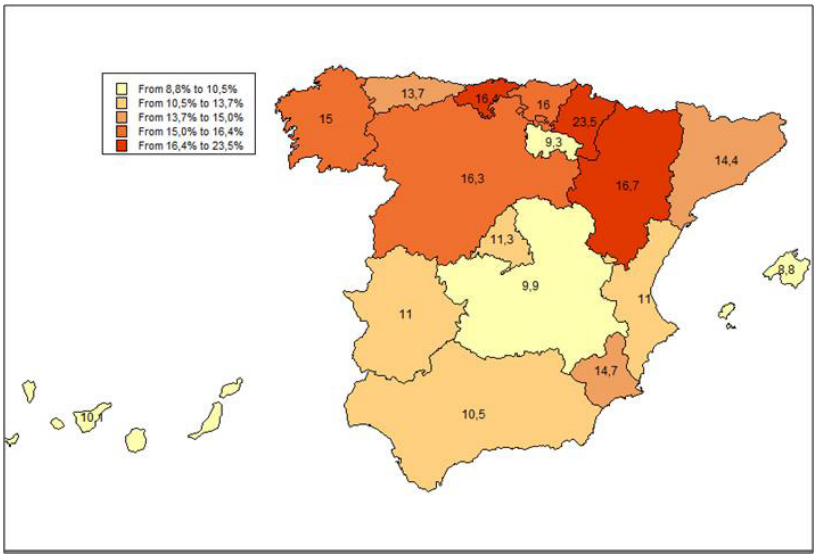


Figure 5-6: Use of CAE techniques (n=6.716).

By Autonomous Community

If the sample is analyzed community by community, Aragón, Asturias, Cantabria, Castilla y León, Cataluña, Galicia, Murcia, Navarra and the Basque Country exceed this mean. The highest percentage is found in Navarra with 23.5%. The sample sizes from each community and the number of companies using CAE in each can be seen in Table 5-2. Map 5-2 shows the percentages corresponding to this table.



Map 5-2: Companies using CAE techniques by Autonomous Community (n=6,716).

AUT. COM.	Use CAE	Total companies AUT. COM.
ANDALUCÍA	86	820
ARAGÓN	35	210
ASTURIAS	17	124
BALEARIC ISLANDS	12	137
CANARY ISLANDS	23	228
CANTABRIA	11	67
CASTILLA-LA MANCHA	21	212
CASTILLA-LEÓN	44	270
CATALUÑA	189	1,310
COMUNIDAD VALENCIANA	78	708
EXTREMADURA	9	82
GALICIA	54	359
MADRID	160	1,418
MURCIA	28	191
NAVARRA	28	119
BASQUE COUNTRY	67	418
LA RIOJA	4	43
Total	**866**	**6,716**

Table 5-2: Companies using CAE techniques in each Autonomous Community.

By sector

As can be seen in Figure 5-7, above the 13% of all the sampled companies using some type of CAE technique, the following sectors are to be found: *Metal and machinery* (29%), *Technical services* (21%), *Energy, chemical and environment* (18%), *Timber and paper* (15%) and *Construction* (14%). The lowest value is found in those companies devoted to *Health*, with 2%; in absolute terms, from the 368 companies forming the sample in this sector, only 7 are involved in *Health.*

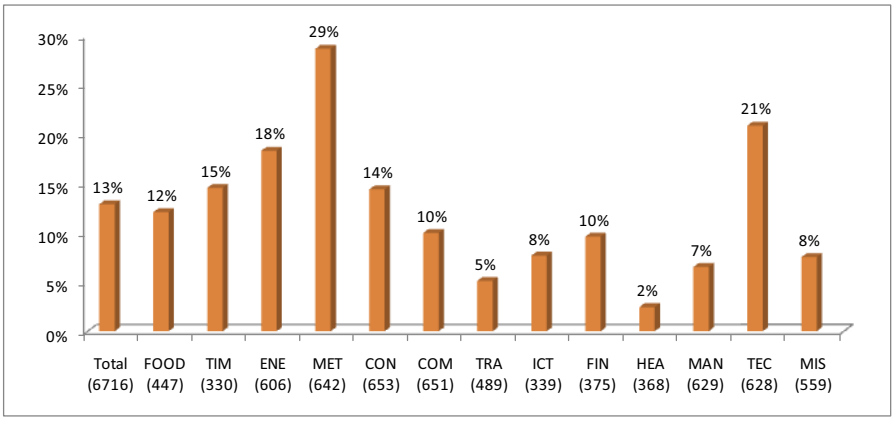


Figure 5-7: Use of CAE techniques against total sample and by sector.

Taking as a base those companies using CAE (n=866) and breaking down by sector, the most noteworthy are the companies engaged in *Metal and machinery* (21%), *Technical services* (15%) and *Energy, chemical and environment* (13%). If this is related to the 7 companies referred to in the previous paragraph that used CAE and were engaged in the *Health* sector, they represent 1% of the total number of companies using CAE. See Figure 5-8.

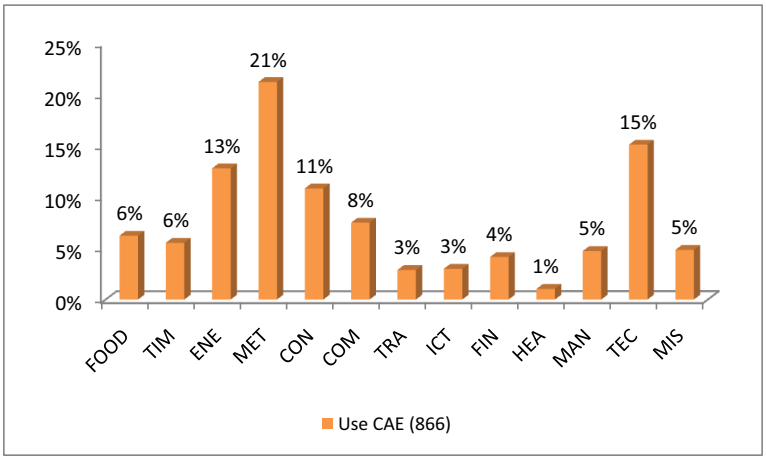


Figure 5-8: Distribution of companies using CAE by sector.

By company size

As can be seen in Figure 5-9, as company size increases, so does the use of these techniques. Thus, in large companies, which constitute 19% of this group, the percentage of those that use CAE exceeds the sample total by 6 percent.

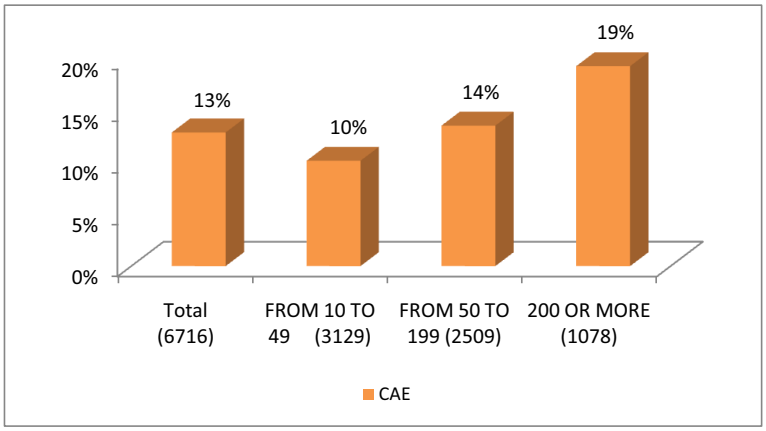


Figure 5-9: Use of CAE techniques against the sample total and by company size.

If once again the companies using CAE techniques (n=866) are taken as the base, then dividing by company size, 76% of such companies would be found among the small and medium-sized firms, only 24% being large companies. See Figure 5-10.

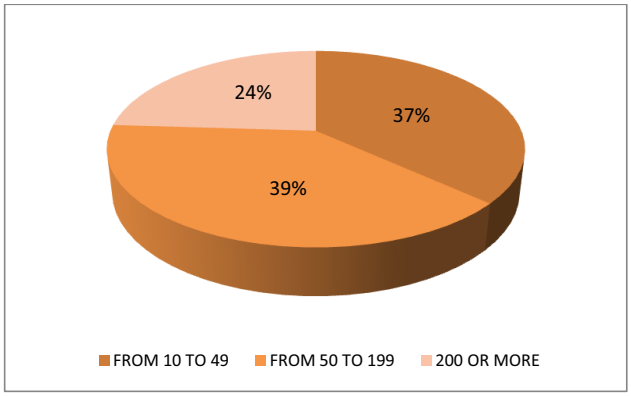


Figure 5-10: Distribution of companies using CAE according to company size (n=866).

5.1.3 Use of CAD and CAE

The set of companies employing both techniques is now analyzed, without the results obtained with CAD necessarily being used for subsequent analysis with CAE.

10% of all companies in the survey use both CAD and CAE techniques. This implies that most companies that use CAE also use CAD applications. Only 3% of companies in the sample would conduct tasks exclusively related to CAE. See Figure 5-11.

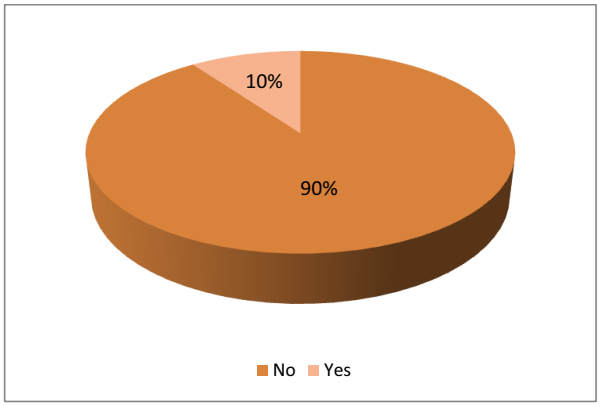


Figure 5-11: Companies using CAD and CAE (n=6,716).

Taking as a base those companies using CAD, the percentage of those that also use CAE would amount to 29%. See Figure 5-12.

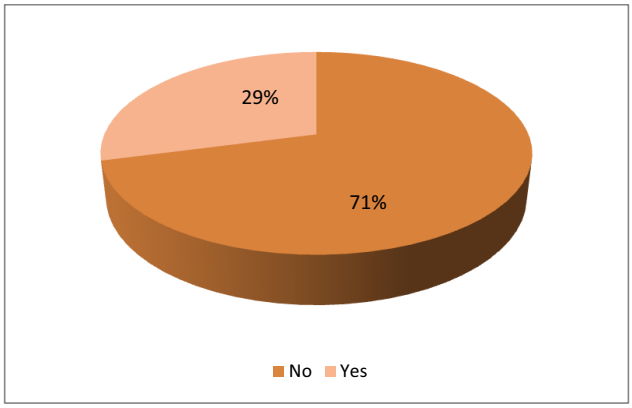


Figure 5-12: Companies using CAE, taking companies using CAD as the base (n=2,301).

By sector

Figure 5-13 shows the values for those companies using both CAD and CAE against the sample total and the total of each sector. If this is compared with Figure 5-7, in which the companies using CAE appear, one may observe that the distribution is analogous. The sectors with the highest percentages are as follows: *Metal and machinery* (27%/ CAE-only was 29%), *Technical services* (18%/ 21%), *Energy, chemical and environment* (15%/ 18%), *Construction* (13%/ 14%) and *Timber and paper* (10%/ 15%). The most significant difference is in the *Metal and machinery* sector, with 5% of companies not using CAD but implementing CAE.

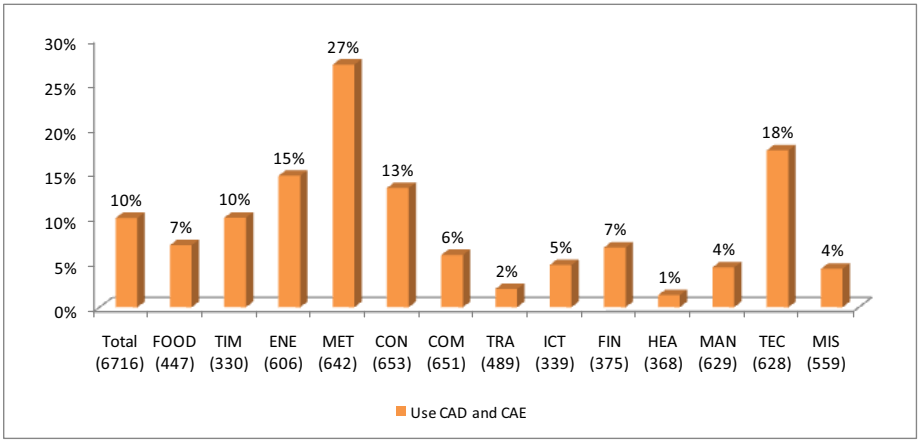


Figure 5-13: Use of CAD and CAE techniques against sample total and by sector.

If the calculation is performed on the sample of companies using CAD (2,301), the highest values are found in the *Metal and machinery (40%)* and *Finance (35%)* sectors. See Figure 5-14.

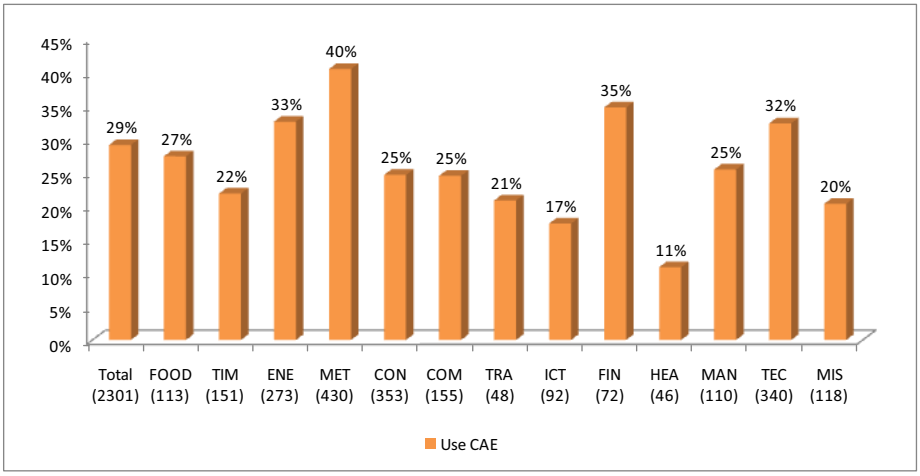


Figure 5-14: Use of CAD and CAE taking CAD users as the base for the total CAD sample and by sector.

As regards distribution by sector, one may observe in Figure 5-15 that the sectors in which these techniques are most widely applied are still *Metal and machinery* (26%), *Technical services* (16%), *Energy, chemical and environment* (13%) and *Construction* (13%). Note, for example, the value for the *Timber and paper* sector (5%); since this is calculated on the basis of the total sample of companies using both CAD and CAE (670), it is therefore influenced from the outset by the size of the sample total of companies using CAD and CAE (330), which in relation with, for example, the *Construction* sector (653), amounts to almost half. Thus, in comparison with its position in Figure 5-13, where it is situated in fifth place, its very low value in Figure 5-15 may give rise to confusion.

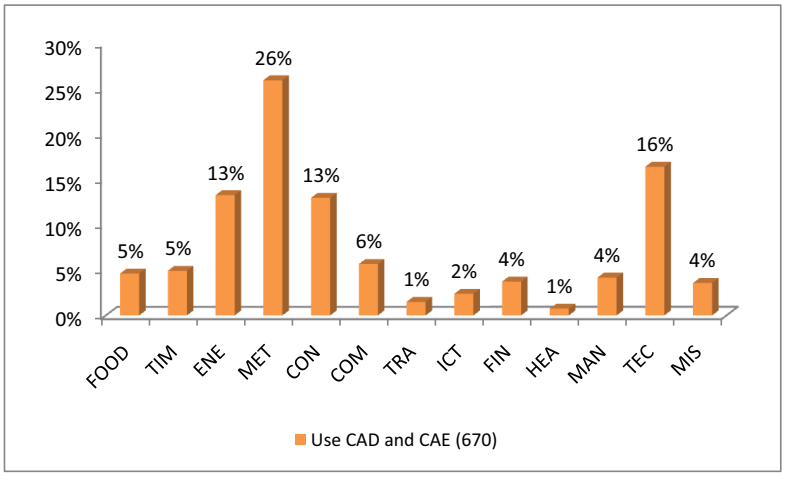


Figure 5-15: Distribution of companies using CAD and CAE by sector.

By company size

As in previous sections, as company size increases, so does the use of these techniques (see Figure 5-16). Thus, in large companies, which constitute 17% of the total in this group, the number of those using CAD and CAE is 10% greater than in small companies.

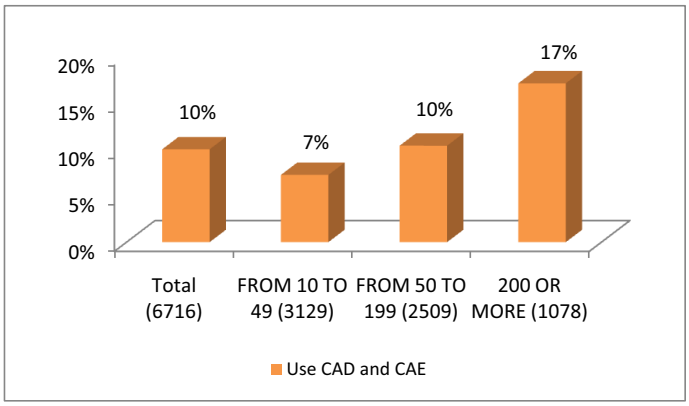


Figure 5-16: Use of CAD and CAE techniques against sample total and by company size.

If one selects from the sample only those companies that use CAD, there is a 5% difference between one company size group and the next, ranging from 25% in small companies to 35% in large companies (see Figure 5-17).

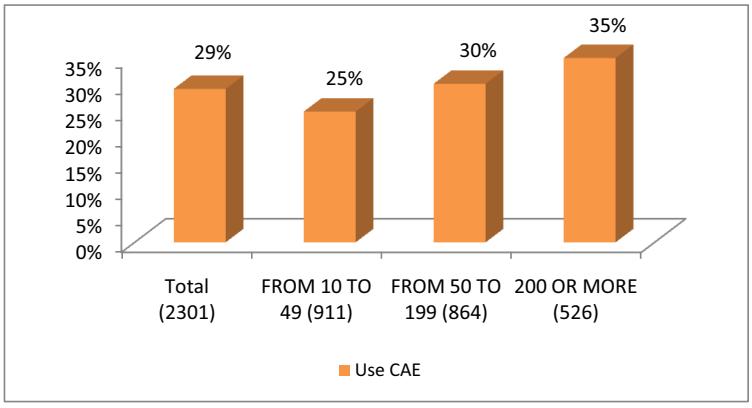


Figure 5-17: Use of CAD and CAE techniques taking CAD users as a base for the total CAD sample and by company size.

As far as distribution by company size is concerned, 73% of the companies in the sample that use CAD and CAE correspond to small and medium-size firms. See Figure 5-18.

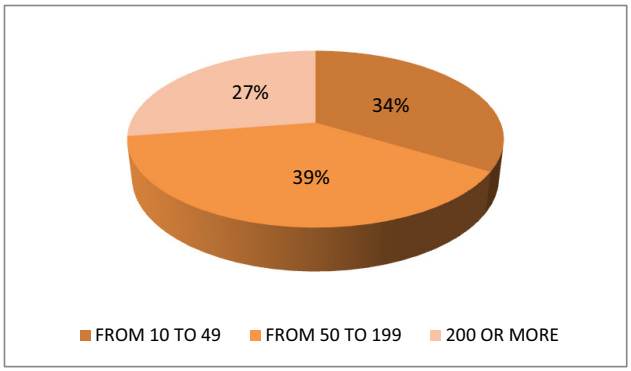


Figure 5-18: Distribution of companies using CAD and CAE by size (n=670).

5.1.4 Use of CAD and subsequent use of results in CAE

In this section, companies employing CAD and then subsequently using CAD results in CAE are analyzed.

We have already seen that 34% of companies use CAD. This amounts to 2,301 companies from the total of 6,716 making up the whole sample. Of this sub-sample, 26% of such companies employ CAE subsequent to CAD by making use of the results obtained from CAD, thus representing 9% of all the companies included in the entire sample. See Figure 5-19 and Figure 5-20.

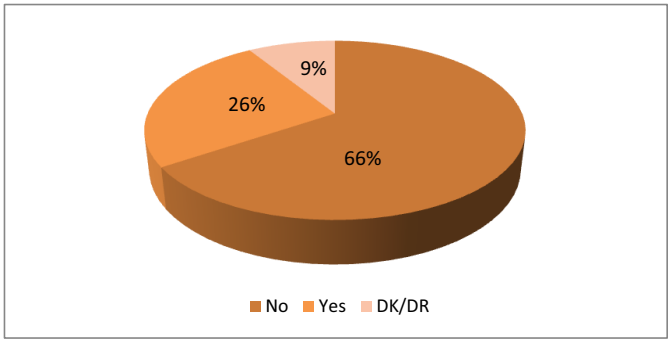


Figure 5-19: Companies within the CAD user group that use CAE as a subsequent application of CAD (n=2,301).

By sector

Figure 5-20 gives the values of both those companies that use CAD (first column) and those that subsequently make use of the results obtained from CAD for CAE applications (second column), shown in comparison with the sample total and the total of each sector.

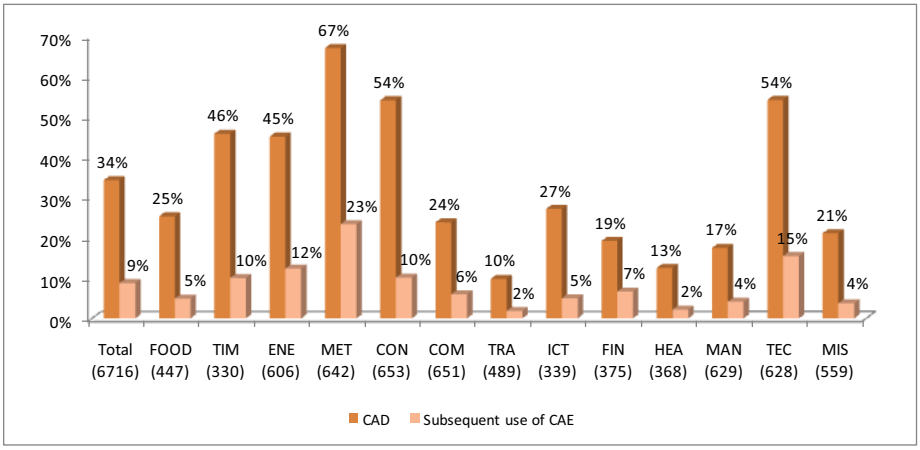


Figure 5-20: Comparison of companies using CAD with those subsequently using the results obtained from CAD for CAE applications, shown against the sample total and the total of companies in each sector.

Table 5-3 shows the percentage of those companies using CAD for each of the sectors as well as those that in addition to using CAD also use CAD results for CAE purposes. For example, in the *Metal and machinery* sector, 67% of companies make use of CAD techniques; of these companies, 35% subsequently use the results obtained from CAD in CAE applications, so that this 35% (Table 5-3 and Figure 5-21) is equivalent to 23% (Figure 5-20) if we take as a basis of reference all the companies belonging to the sector in the general sample (642) rather than only the companies belonging to the sector recorded as using CAD (430).

Sector	CAD	Subsequent use of CAE
FOOD	25%	19%
TIM	46%	22%
ENE	45%	27%
MET	67%	35%
CON	54%	19%
COM	24%	25%
TRA	10%	19%
ICT	27%	18%
FIN	19%	35%
HEA	13%	17%
MAN	17%	24%
TEC	54%	29%
MIS	21%	18%
Sample Total	**34%**	**26%**

Table 5-3: Percentage of companies using CAE as a subsequent application of CAD results, by sector.

The following graph shows the percentages from the second column of Table 5-3, from which the 2,301 companies responding affirmatively to Question C4 "*Does your company use CAD?*" are taken as a sample.

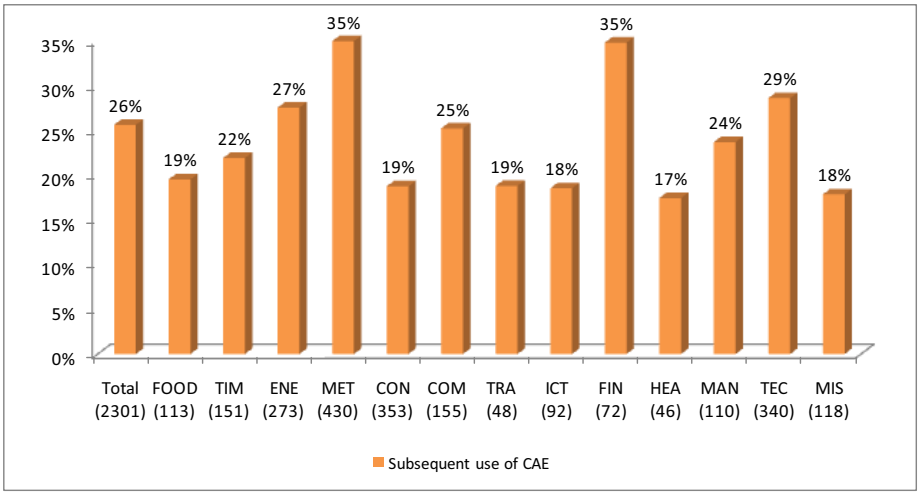


Figure 5-21: Companies subsequently using CAE with results previously obtained from CAD, in comparison with CAD users in the sample and CAD users in each sector.

On comparison of each of the sectors with the overall behavior of the sample (Figure 5-21), one observes that the *Metal and machinery* (35%) and *Finance* (35%) sectors, followed by *Technical services* (29%), *Energy, chemical and environment* (27%) exceed this overall value. The lowest values are to be found in the *Health* (17%), *ICT and Miscellaneous services* (18%), *Food and clothing, Construction, Transport and storage* sectors (19%).

If the study is restricted to the 588 companies that make subsequent use of CAE after CAD, one observes that 26% of these belong to the *Metal and machinery* sector, 16% to the *Technical services* sector, 13% to the *Energy, chemical and environment* sector, and 11% to the *Construction* sector. The remaining 34% would be distributed over the other sectors. See Figure 5-22.

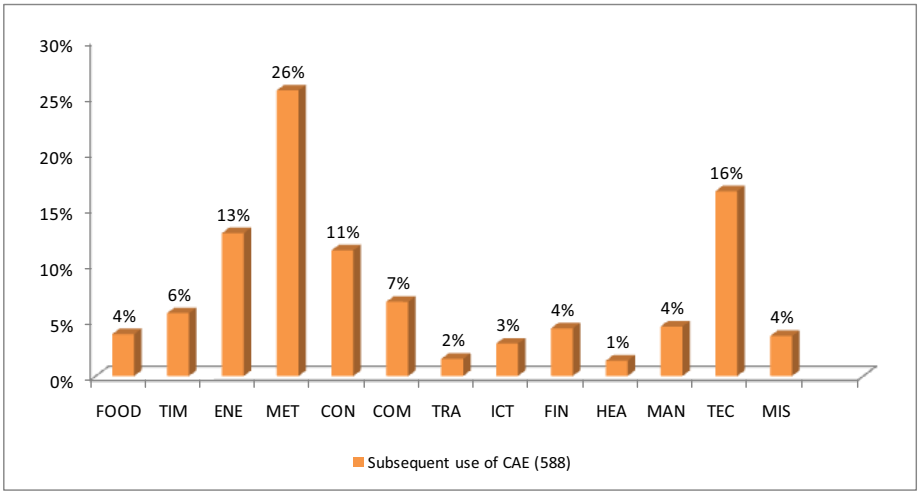


Figure 5-22: Distribution of companies using CAE subsequent to the use of CAD, by sector.

By company size

As stated above, approximately 26% of the companies that use CAD also make use of CAE techniques, which amounts to 9% of the total sample. This value increases in those companies with a workforce higher than 199 persons, thereby rising to 15%, which would be equivalent to 31% of the large companies that use CAD and subsequently employ CAD results for CAE purposes. See Figure 5-23 and Table 5-4.

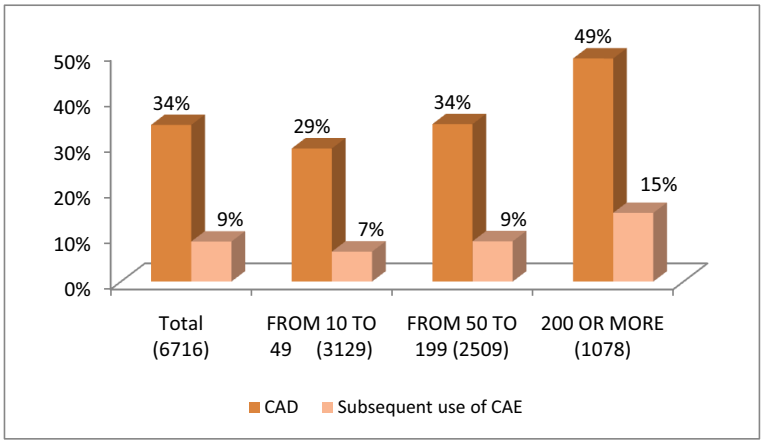


Figure 5-23: Comparison of companies using CAD with companies belonging to the CAD group subsequently making use of CAE, shown against the sample total and the total of companies by size.

Company size	CAD	Subsequent use of CAE
FROM 10 TO 49	29%	23%
FROM 50 TO 199	34%	26%
200 OR MORE	49%	31%
Sample total	34%	26%

Table 5-4: Percentage of companies with subsequent CAE use belonging to CAD user group, by company size.

As regards the small company group, 23% of such companies make subsequent use of CAD results in CAE applications. This amounts to 7% of the total of companies in the sample with fewer than 50 employees. See Figure 5-23 and Figure 5-24.

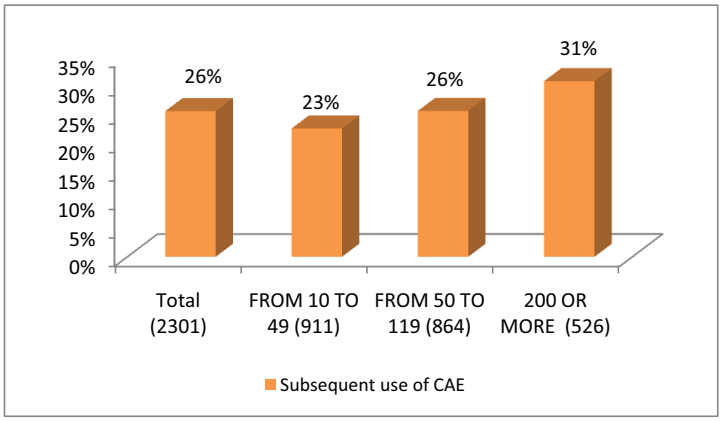


Figure 5-24: CAD user companies subsequently using CAE compared against CAD user sample and CAD users by size.

If the percentages are calculated against the total of companies subsequently using CAD results in CAE applications (n=588), then practically 73% of such companies are seen to belong to the small and medium-size category. See Figure 5-25.

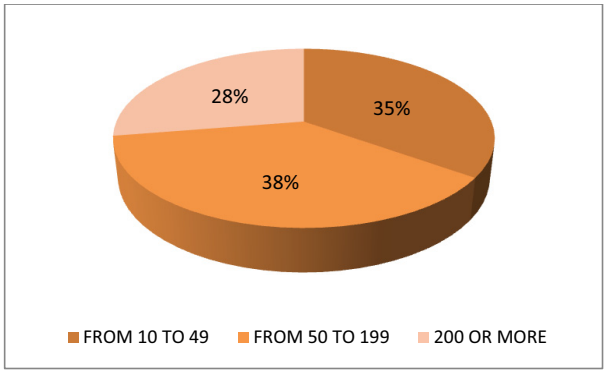


Figure 5-25: Distribution of companies subsequently using CAE after CAD, by company size (n=588).

5.1.5 Use of CAE but not CAD

Within the group of companies using CAE, which amount to 13% of the total sample (n= 866), 23% do not use CAD techniques. See Figure 5-26.

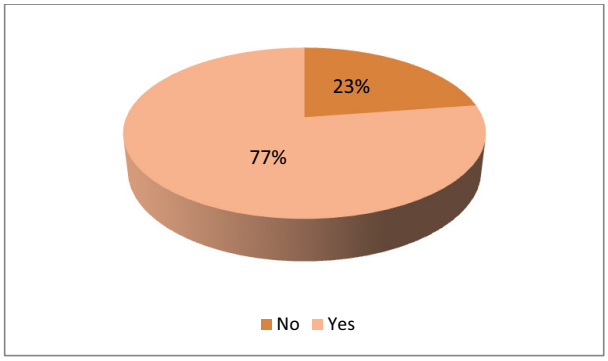


Figure 5-26: Companies in the CAE group that do not use CAD (n=866).

By sector

Analogously to the previous section, Figure 5-27 shows the values corresponding to both CAE user companies (first column) and CAE users that do not make use of CAD (second column) as compared against the sample total and the total of each sector. Thus, if we wish to represent this 23% of companies which, having employed CAE techniques, do not make use of CAD as compared against the total number of companies in the sample, this would give a value of 3%.

If, for example, the *Metal and machinery* sector is analyzed, where 29% of companies use CAE techniques, only 5% of these companies do not make prior use of CAD. This amounts to 2% of all the companies in the sector. See Table 5-5 and Figure 5-27.

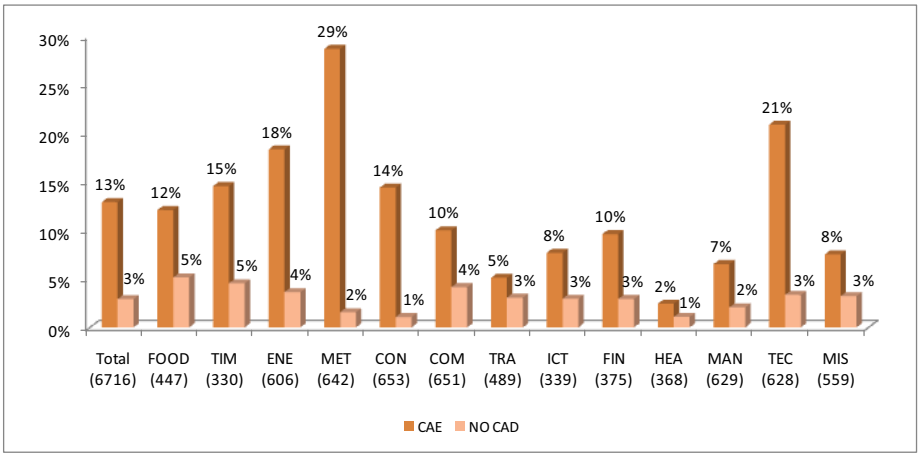


Figure 5-27: Comparison of CAE user companies with non-CAD users within the CAE user group, shown against the sample total and the total number of companies in each sector.

Sector	CAE	No CAD
FOOD	12%	43%
TIM	15%	31%
ENE	18%	20%
MET	29%	5%
CON	14%	7%
COM	10%	42%
TRA	5%	60%
ICT	8%	38%
FIN	10%	31%
HEA	2%	44%
MAN	7%	32%
TEC	21%	16%
MIS	8%	43%
Total sample	13%	23%

Table 5-5: Percentage of non-CAD user companies belonging to the CAE user group, by sector.

If the CAE user companies (n=866) are taken as the base and segmentation is performed by sector, the sectors with values considerably higher than the overall percentage (23%) are as follows: *Food and clothing*, *Timber and paper*, *Commerce*, *Transport and storage*, *ICT*, *Finance*, *Health*, *Management services* and *Miscellaneous services*, with a range from 31% to 60%. On the other hand, we would find the *Metal and machinery* and *Construction* sectors, with a very low percentage of companies that use CAE techniques without having obtained any CAD results on their own behalf. See Figure 5-28.

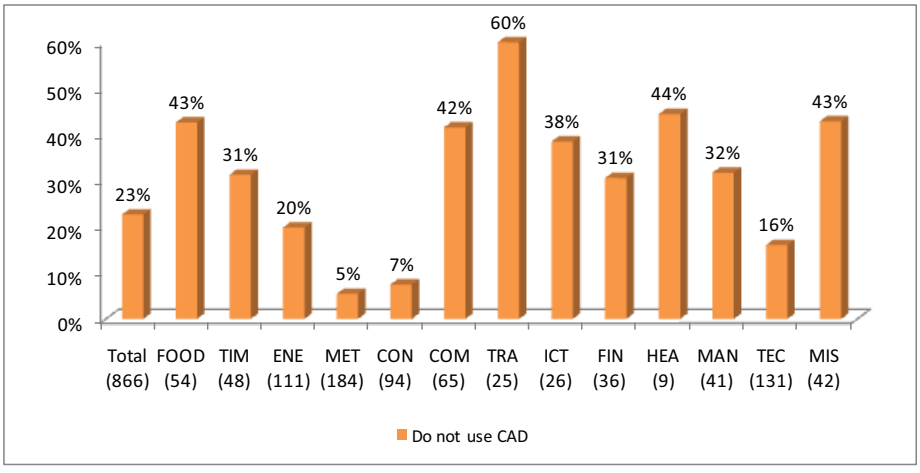


Figure 5-28: Non-CAD user companies belonging to the CAE user group, shown against the CAE user sample and CAE users in each sector.

If we now take the companies belonging to CAE group (n=196) that do not use CAD techniques, the distribution as regards the total of such companies (196) would be as follows:

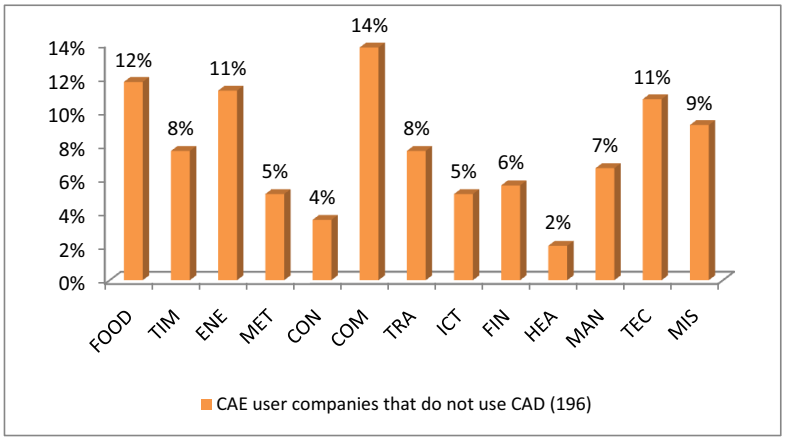


Figure 5-29: Distribution of companies that do not use CAD prior to the use of CAE, by sector.

By company size

As regards comparison by company size, the percentage of firms that while using CAE techniques do not use CAD tools is lower in the large company group. If the calculation is made with respect to the total number of large companies, this figure would be 2% (see Figure 5-30), which is equivalent to the 12% calculated on those companies using CAE that appears in Table 5-6.

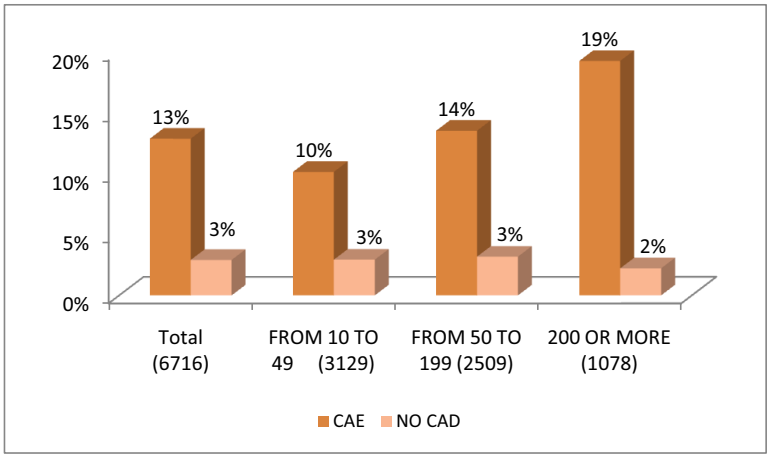


Figure 5-30: Comparison of CAE user companies with those not using CAD in the CAE user group, with respect to the sample total and the total number of companies, by company size.

Sector	CAE	Non-CAD users
FROM 10 TO 49	10%	29%
FROM 50 TO 199	14%	24%
200 OR MORE	19%	12%
Total sample	13%	23%

Table 5-6: Percentage of non-CAD user companies belonging to the CAE user group, by company size.

Table 5-6 is represented in Figure 5-31, where the 866 companies that use CAE are divided according to company size, in terms of whether or not they use CAD techniques.

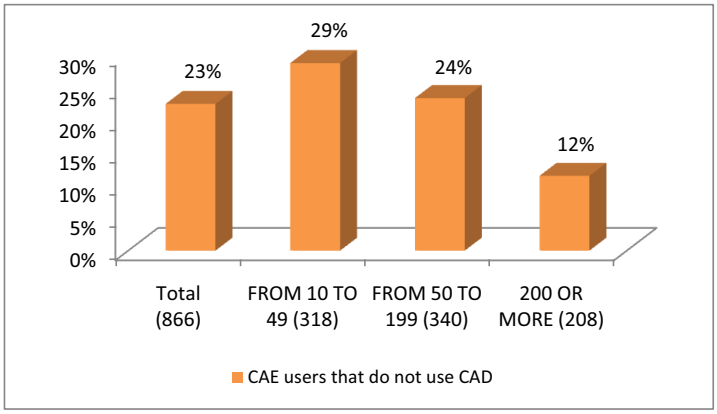


Figure 5-31: Non-CAD user companies belonging to the CAE user group compared against the CAE user sample and CAE users, by company size.

The distribution of non-CAD user companies belonging to the CAE user group (n=196), according to company size, can be seen below. See Figure 5-32.

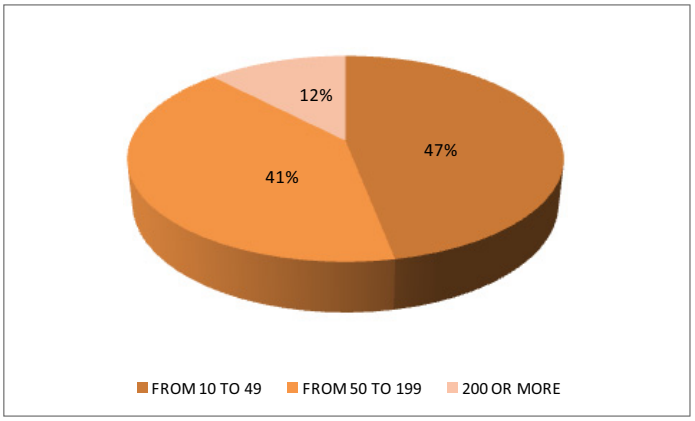


Figure 5-32: Distribution of companies not using CAD but using CAE, by company size (n=196).

5.2 Interlocutors in CAD/CAE

5.2.1 Interlocutors in CAD

In this section we analyze the positions held in CAD user firms by the employees belonging to these companies who responded to the survey. See Figure 5-33. Note that in included in the *Remaining interlocutors* group are those *Responsible for IT, Director/manager and Other (responsible for administration, administrative post, etc.).* It is necessary to point out the high percentage of those belonging to *Remaining interlocutors* who responded, while only 4% stated they were *Responsible for quality,* and 3% of interlocutors saying they were *Responsible for research, development, innovation or engineering,* figures equal to those for *Responsible for methods, schedules, organization or technical department.* Given that those interlocutors well-versed in the area they were asked about may possibly be in a minority, some of the replies should be regarded with caution.

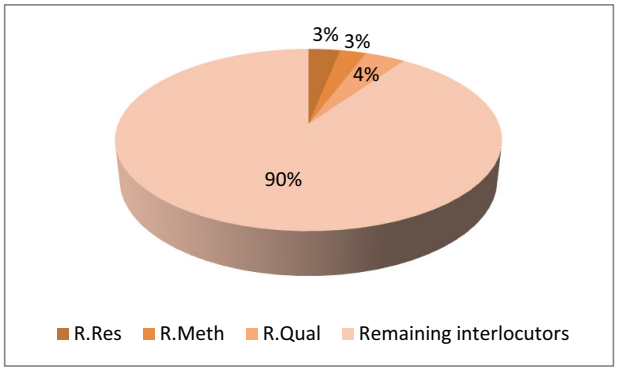


Figure 5-33: Distribution of interlocutors belonging to companies using CAD (n=2,301).

When the sample is divided into four groups according to the type of interlocutor responding to the survey, Figure 5-34 shows the percentages of those companies that stated they used some type of CAD technique. This graph indicates that replies may be conditioned by the post held by the interlocutor in the company: one moves from a figure of 34% for all the companies stating they used CAD to a figure of 58% if the interlocutor held a post *responsible for research, development, innovation or engineering*, to 57% if the reply corresponded to *Responsible for methods, schedules, organization and technical department,* and 43% if the reply was *Responsible for quality,* all of them values that are considerably higher than the sample total. However, it should not be forgotten that 38% of companies stated that they possessed none of these departments.

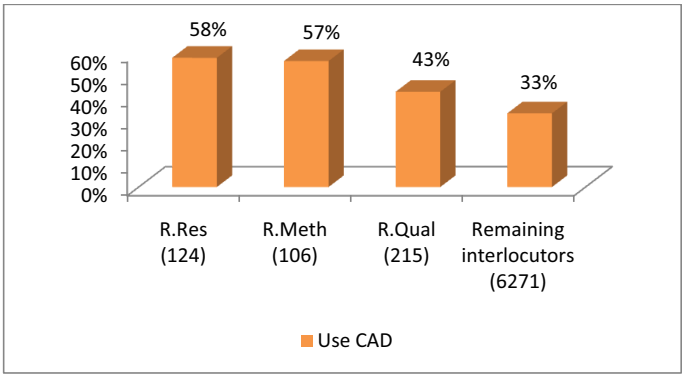


Figure 5-34: CAD user companies, according to interlocutor type.

By sector

If the overall result is compared with that of each of the sectors, few differences are found with regard to who responded to the survey. In each of the sectors, practically 90% of the interviewees belonged to the afore-mentioned *Remaining interlocutors* profile. It is worth noting the 15% of interlocutors belonging to the *Responsible for research, development, innovation or engineering, Responsible for methods, schedules organization or technical department and Responsible for quality* profiles in the *Technical services* sector. See Figure 5-35.

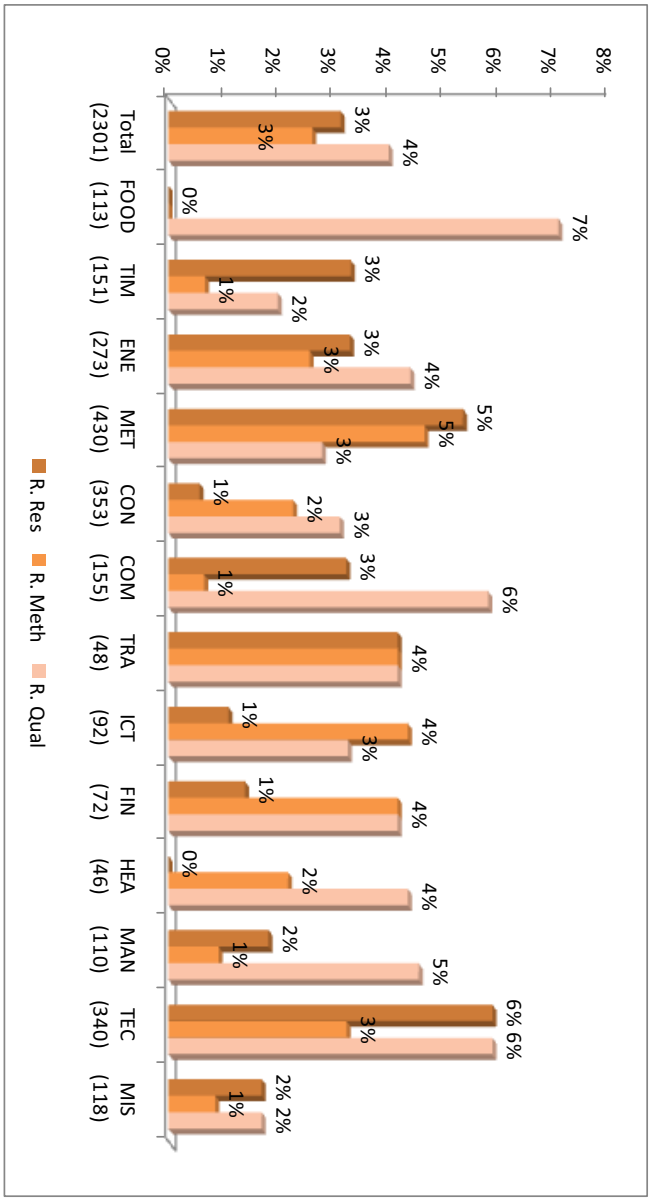


Figure 5-35: Analysis of interlocutors belonging to CAD user companies, by sector.

5.2.2 Interlocutors in CAE

Those companies that make use of CAE are now analyzed. Analogously to the foregoing section, 87% of those interviewed belong to the *Remaining interlocutors* group, which covers the *Responsible for IT, Director/manager and Others (responsible for administration, administrative post, etc.)* profiles. Only 5% are *Responsible for quality and Responsible for research, development, innovation and engineering,* while 3% of interviewees belong to *Responsible for methods, schedules, organization or technical department.* See Figure 5-36.

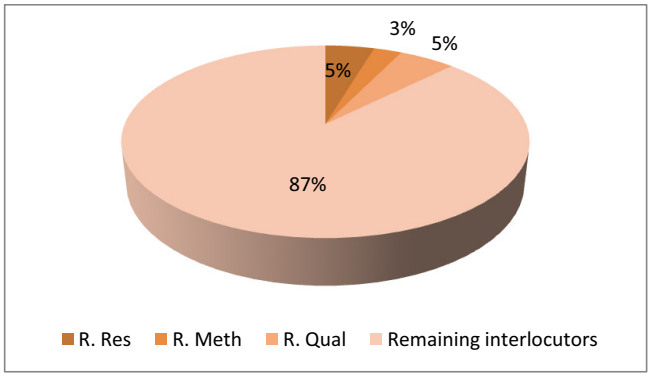


Figure 5-36: Distribution of interlocutors belonging to CAE user companies (n=866).

When the sample is divided into four groups according to the type of interlocutor who responded to the survey, Figure 5-37 shows the percentages of those companies stating that they use some type of CAE technique. This graph indicates that the response may be affected by the position held by the interlocutor within the company: from a figure of 13% of the total of companies stating that they use CAE, this rises to 32% if the interlocutor holds a post *Responsible for research, development, innovation or engineering,* to 22% in the case of responses for *Responsible for methods, schedules, organization and technical department,* and to 21% if the response corresponds to *Responsible for quality,* all of them values considerably higher than the sample total. It is important to point out that although 62% of the companies possess some of these departments, none of the people responsible for them replied to the survey.

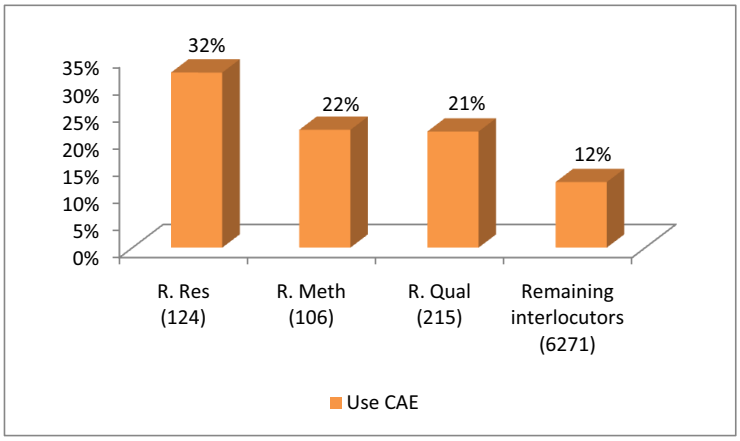


Figure 5-37: CAE user companies according to type of interlocutor.

By sector

If once again the overall result is compared with that of each of the sectors, it is noteworthy the 20% of interlocutors with a profile corresponding to *Responsible for research, development, innovation or engineering, Responsible for methods, schedules, organization or technical department* and to *Responsible for quality* in the *Technical Services and ICT* sectors. See Figure 5-38.

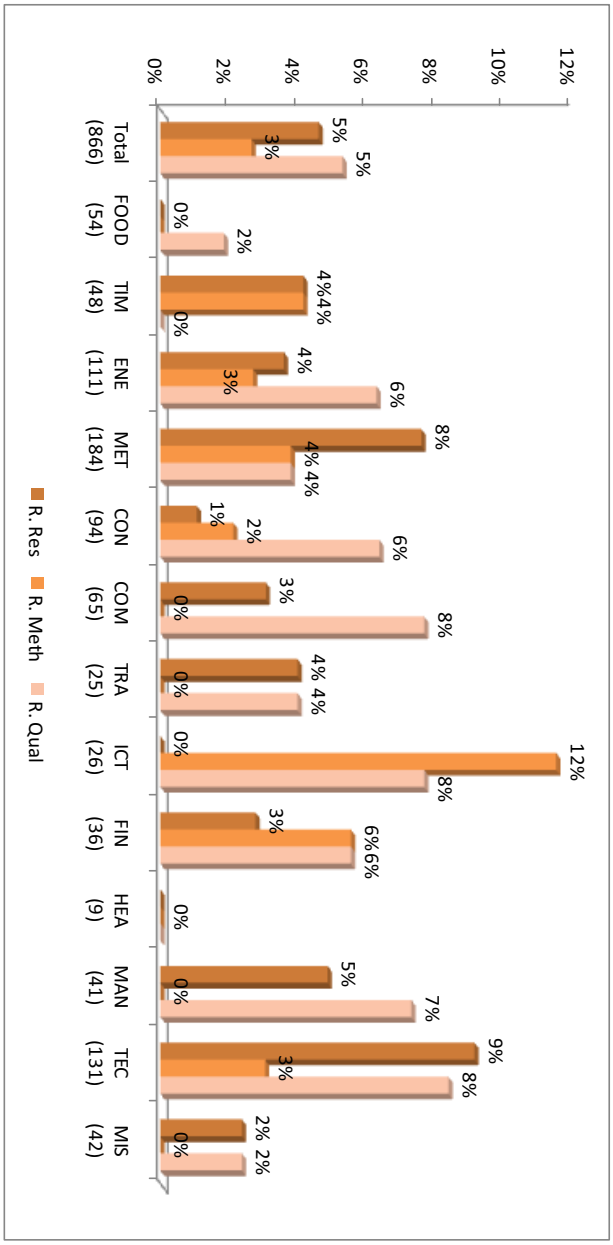


Figure 5-38: Analysis of interlocutors belonging to CAE user companies, by sector.

5.3 How CAE is used

In this section, the companies using CAE tools are analyzed, irrespective of whether CAE techniques are employed internally within the company, externally, or both.

Figure 5-39 shows that 85% of the companies in the survey make use of CAE, with 22% of this total employing CAE both internally and externally.

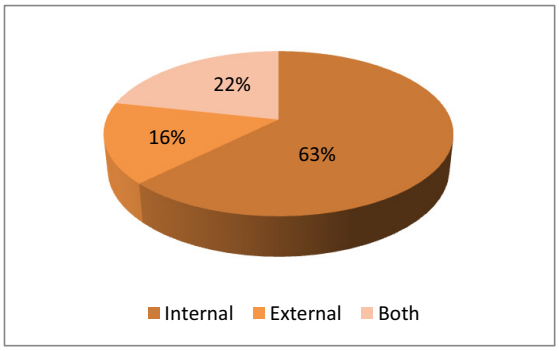


Figure 5-39: Companies using CAE, according to where CAE is carried out (n=866).

By sector

When analyzed by sector, internal use of CAE increases in *ICT* and *Management services*, where in only 8% and 10% of companies, respectively, is CAE exclusively conducted externally. See Figure 5-40.

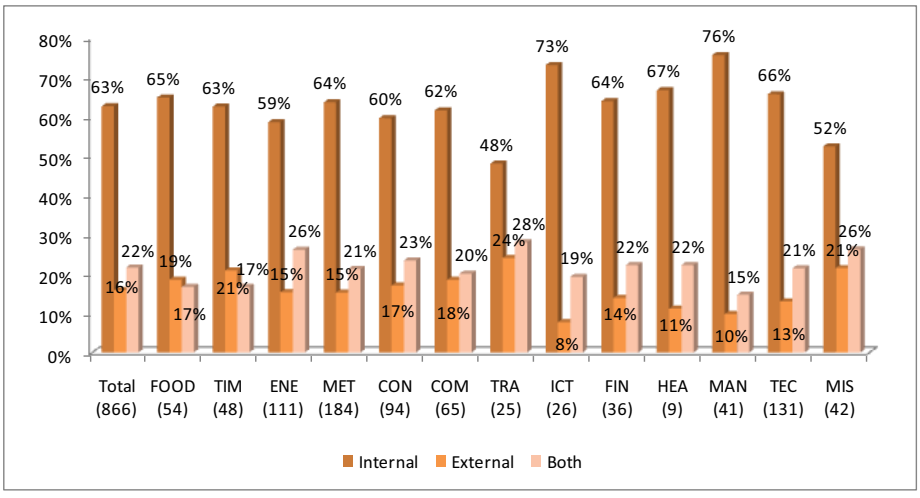


Figure 5-40: CAE user companies according to where CAE is conducted, by sector.

By company size

When compared by size, the largest companies are those which make least conduct of CAE only externally, with a figure of 12%. See Figure 5-41.

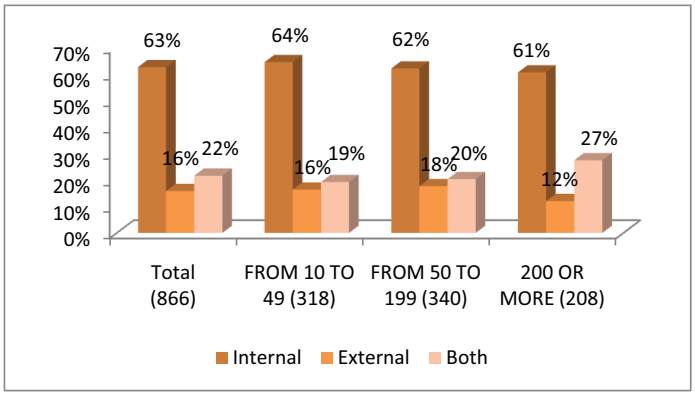


Figure 5-41: CAE user companies according to where CAE is conducted, by company size.

5.3.1 Type of software employed in internally conducted CAE

In this section, those companies that conduct CAE internally are considered, together with a study of the type of software used, according to whether it is commercial or free software or both.

Of the 729 companies that conduct CAE internally, 83.8% employ commercially available software. Only 16.2% of companies employ free software on an exclusive basis. See Figure 5-42.

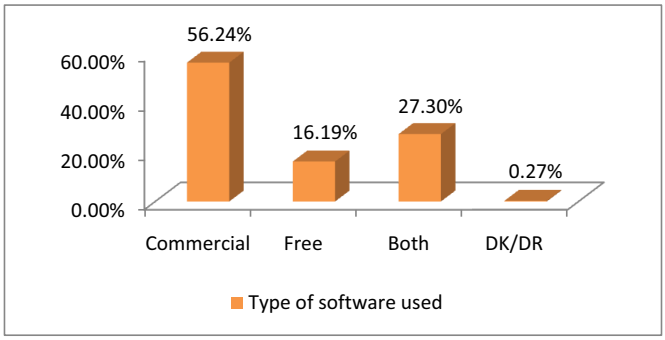


Figure 5-42: Companies that employ CAE internally, according to the type of software used (n=729).

By sector

One may observe in Table 5-7 that exclusive use of free software is less in the *Metal and machinery* (9%) and *Miscellaneous services* (3%) sectors, with figures of 33% and 27%, respectively, taking into account those companies stating that they use both types of software. Those sectors showing the highest percentages are *ITC* (67%), *Construction* (53%) and *Health* (50%), in which free software is most widely used. See Figure 5-43.

Sector	Commercial	Free	Both	DK/DR
FOOD (44)	64%	16%	20%	0%
TIM (38)	50%	18%	32%	0%
ENE (94)	56%	17%	27%	0%
MET (156)	66%	9%	24%	1%
CON (78)	47%	21%	32%	0%
COM (53)	55%	26%	19%	0%
TRA (19)	53%	21%	26%	0%
ICT (24)	33%	21%	46%	0%
FIN (31)	52%	13%	35%	0%
HEA (8)	50%	25%	25%	0%
MAN (37)	49%	24%	27%	0%
TEC (114)	54%	17%	30%	0%
MIS (33)	73%	3%	24%	0%
Total (729)	**56%**	**16%**	**27%**	**0%**

Table 5-7: Companies that conduct CAE internally, according to type of software used and by sector.

The following graph shows the percentages of those companies stating that they use free software or both types.

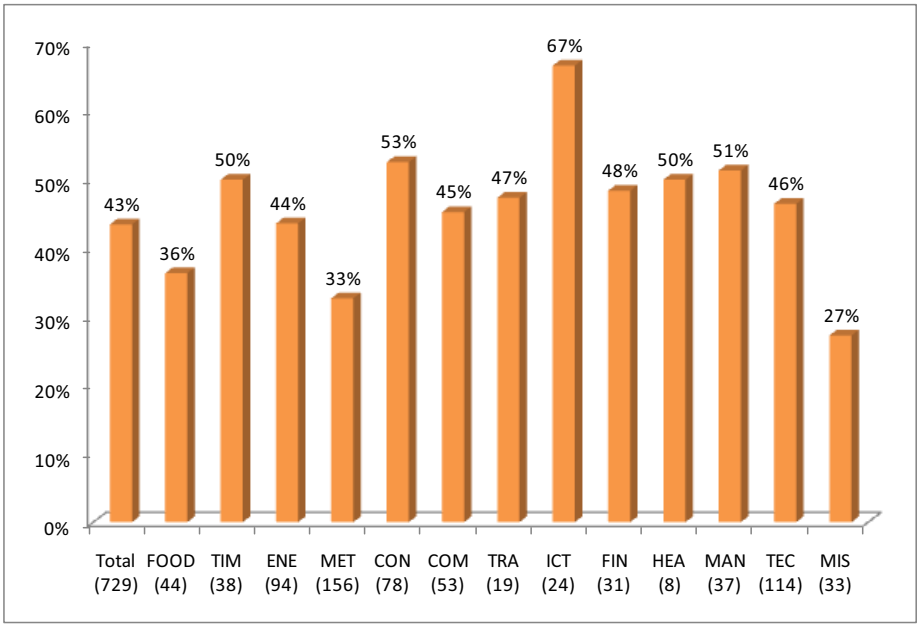


Figure 5-43: Companies that conduct CAE internally with free software (n=729).

By company size

Analysis according to company size shows differences in terms of the type of software used, the smallest companies making the least use of commercial software, with a value of 80%. See Figure 5-44.

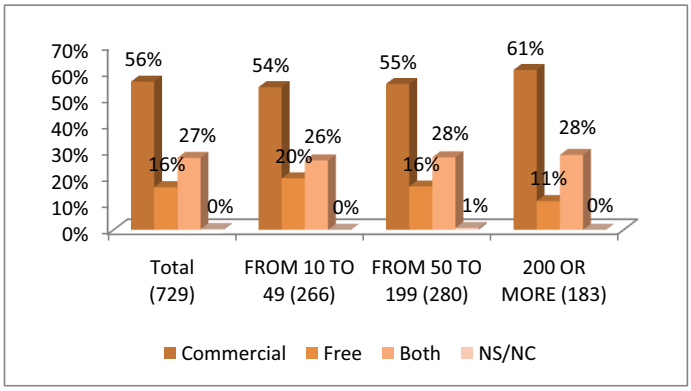


Figure 5-44: Companies that employ CAE internally according to type of software used, by company size.

5.3.2 CAE carried out internally with customized CAE programs or modules

Figure 5-45 shows that 46% of the companies conducting CAE internally use customized programs for that purpose.

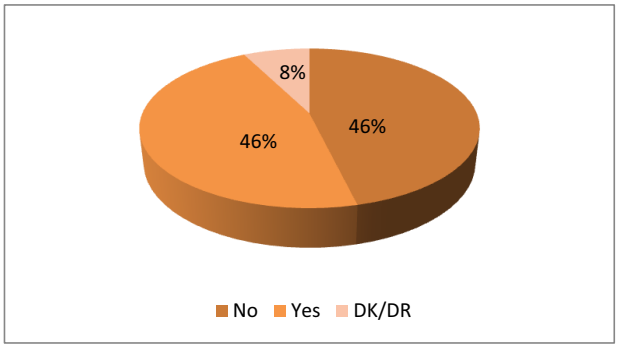


Figure 5-45: Companies carrying out CAE internally according to their use of customized CAE programs or modules (n=729).

By sector

In the comparison by sector, this figure of 46% of the total sample increases considerably in the *Health* (75%), *Timber and paper* (66%) and *Finance* (61%) sectors. See Table 5-8.

Sector	No	YES	DK/DR
FOOD (44)	34%	59%	7%
TIM (38)	26%	66%	8%
ENE (94)	48%	43%	10%
MET (156)	53%	36%	12%
CON (78)	47%	46%	6%
COM (53)	40%	57%	4%
TRA (19)	37%	58%	5%
ICT (24)	42%	46%	13%
FIN (31)	35%	61%	3%
HEA (8)	25%	75%	0%
MAN (37)	41%	59%	0%
TEC (114)	58%	36%	6%
MIS (33)	48%	42%	9%
Total (729)	**46%**	**46%**	**8%**

Table 5-8: Companies employing CAE internally according to their use of customized CAE programs or modules, by sector.

By company size

No significant differences are found on comparison by company size. See Figure 5-46.

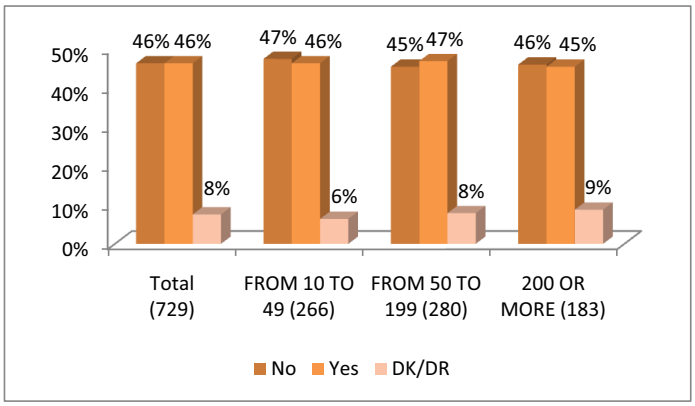


Figure 5-46: Companies employing CAE internally according to their use of customized CAE programs or modules, by company size.

5.4 Type of CAE carried out

In the following section we focus on the companies in the sample that state that they use CAE techniques, which provide a working base of 866 firms.

As regards the purpose for which these companies use CAE, question C7 referred to classification according to the following areas:

1: Mechanical or structural.
2: Thermal or thermodynamics.
3: Manufacturing processes: injection, machine pressing, forging, etc.
4: Electronic and/or electromagnetic.
5: Fluids: gases, liquids.
6: Acoustics or vibro-acoustics.
7: Environmental.
8: Others, such as multiphysics.

50% of replies fall within *Mechanical or structural* and 39% in *Manufacturing processes*. Note that, given the fact that the question invited a multiple response, a company may have indicated one or several of the purposes and areas mentioned above. See Figure 5-47.

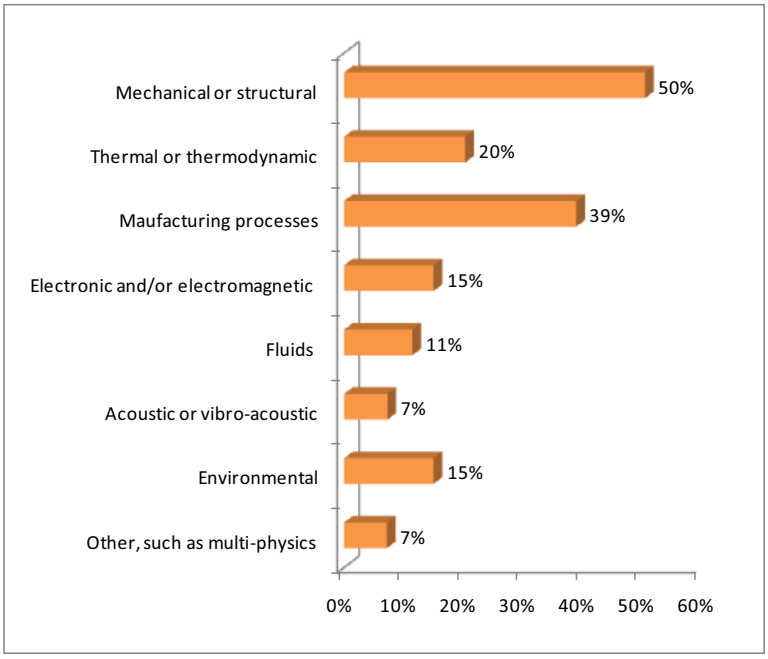


Figure 5-47: Type of CAE carried out (n=866).

By sector

Table 5-9 gives the percentages against the total number of companies using CAE in each sector. One may observe that in the *Food and clothing* sector, 70% of the 29 companies that employ CAE in the sector apply these techniques to *Manufacturing processes* and 19% in analysis of a *Mechanical or structural* type. It is worth noting, however, that half the number of companies using CAE in the *Finance* sector do so in order to simulate *Mechanical or structural* phenomena and 17% *Thermal or thermodynamic* phenomena.

Sector	Mechanical or structural	Thermal or thermodynamic	Manufacturing processes	Electronic and/or electromagnetic	Fluids	*Acoustic or vibro-acoustic*	*Environmental*	*Others (e.g. multi-physics)*
FOOD (54)	19%	9%	70%	4%	6%	0%	6%	4%
TIM (48)	38%	4%	65%	4%	2%	2%	2%	6%
ENE (111)	41%	25%	49%	9%	17%	7%	23%	5%
MET (184)	63%	24%	49%	21%	13%	7%	9%	2%
CON (94)	60%	21%	35%	14%	13%	13%	18%	4%
COM (65)	37%	17%	43%	20%	9%	5%	9%	9%
TRA (25)	56%	20%	16%	16%	16%	8%	24%	16%
ICT (26)	27%	12%	35%	38%	0%	8%	8%	0%
FIN (36)	50%	17%	17%	6%	6%	8%	14%	19%
HEA (9)	56%	0%	33%	0%	0%	0%	22%	22%
MAN (41)	61%	20%	2%	22%	5%	5%	20%	12%
TEC (131)	64%	27%	20%	18%	18%	11%	24%	11%
MIS (42)	36%	17%	31%	10%	5%	10%	19%	12%
Total (866)	**50%**	**20%**	**39%**	**15%**	**11%**	**7%**	**15%**	**7%**

Table 5-9: Type of phenomena for which CAE is used, by sector.

By company size

Analysis according to company size and for each CAE application shows that large companies simulate *Mechanical or structural*, *Thermal or thermodynamic*, *Electronic and/or electromagnetic*, *Fluids: gases, liquids* and *Acoustic or vibro-acoustic* phenomena more in comparison with small or medium-sized firms. On the other hand, small companies use CAE more in *Environmental* and *Others, such as multiphysics* simulations than large firms. See Figure 5-48.

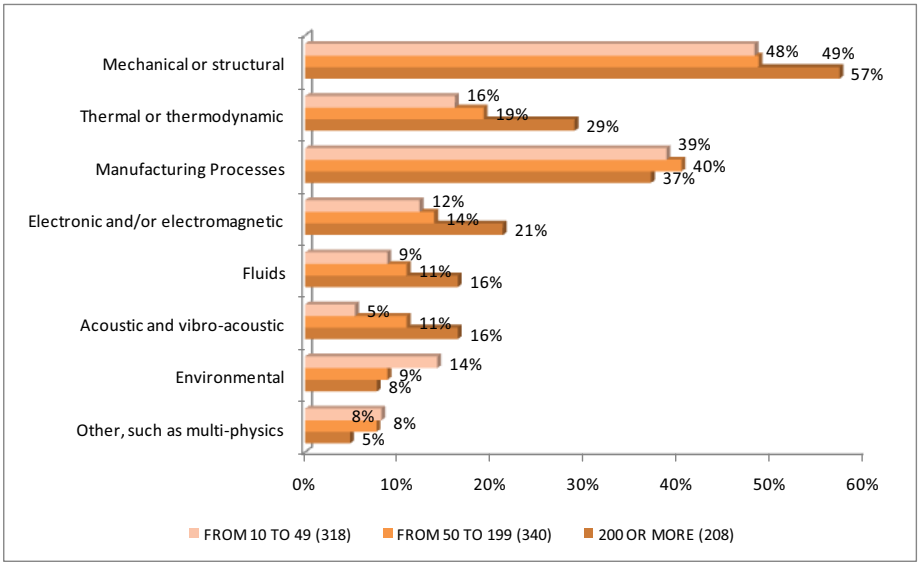


Figure 5-48: Type of CAE simulations carried out according to company size.

The table below shows the companies that use only one type of CAE. Of the 866 companies that make use of some type of CAE application, 66% answered the multiple response C7 question with only one of the possible options, which means that at present they are engaged in only one sphere of application. Table 5-10 gives the number of companies that apply CAE to only one type of phenomenon, as well as the corresponding percentage against the total number of companies using CAE, in terms of the type of CAE carried out. Thus, for example, one observes that the 26% of companies that use CAE do so only for processes of the *Mechanical or structural* type, while 23% of these companies use CAE for *Manufacturing processes*.

Type of CAE	Nº Companies	%
Mechanical or structural	227	26%
Thermal or thermodynamic	28	3%
Manufacturing processes	201	23%
Electronic and/or electromagnetic	29	3%
Fluids	7	1%
Acoustic and vibro-acoustic	5	1%
Environmental	27	3%
Others, such as multiphysics	51	6%
Total: Only one type of CAE	**575**	**66%**

Table 5-10: Type of CAE carried out in companies using only one CAE application (n=866).

5.5 CAD/CAE Requirements

All the companies taking part in the survey were asked if they had any requirements regarding CAD or CAE; for example, if they needed information or assessment about applicability of these techniques; training; implantation, development or improvement of programs. 3.5% of the sample total replied that they required some assistance. This amounts to 235 companies stating that they needed help with CAD/CAE techniques. See Figure 5-49.

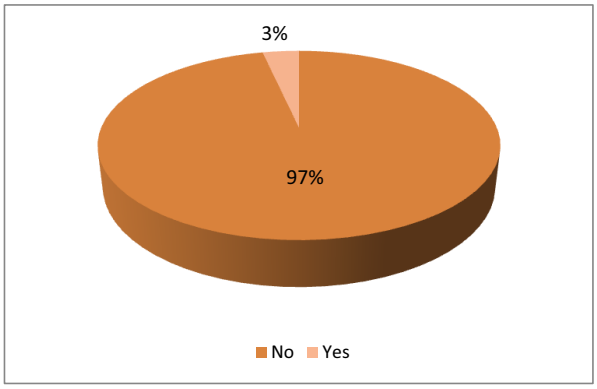


Figure 5-49: CAD/CAE requirements (n=6,716).

By sector:
From calculation of the percentages against the total number of companies in each sector, this requirement increases in those sectors involving *Metal and machinery* (7*%), Construction* (5%) and *Technical Services* (5%). See Figure 5-50.

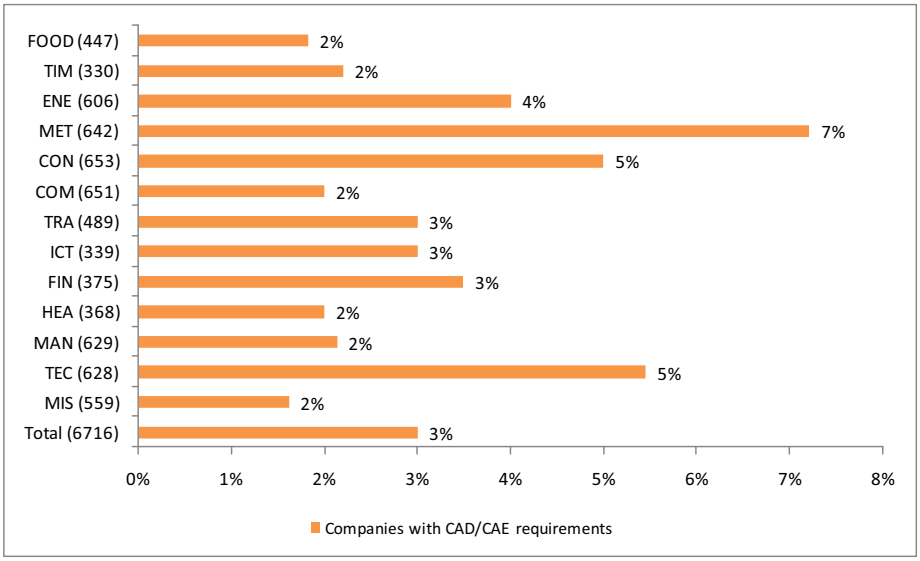


Figure 5-50: CAD/CAE requirement in the sample total, by sector.

By company size

As regards company size, no appreciable differences are found in terms of a greater or lesser degree of need for information or assessment about subjects concerning CAD/CAE. See Figure 5-51.

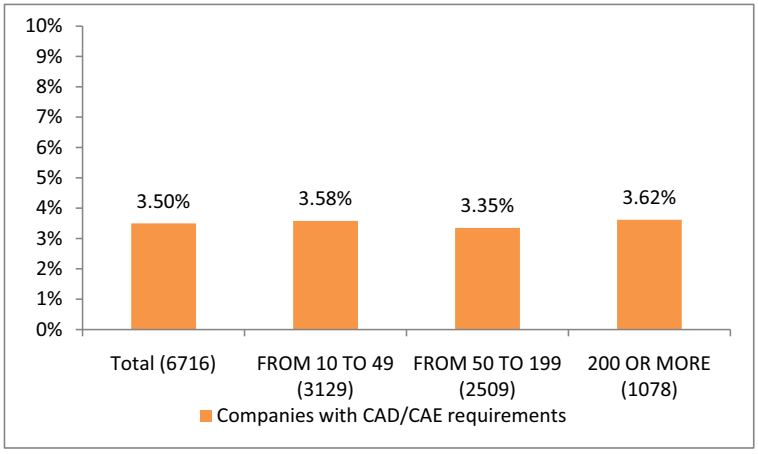


Figure 5-51: CAD/CAE requirements in the sample total, by company size.

5.5.1 Type of CAD/CAE requirements

Those companies that stated their need for assistance in subjects relating to CAD/CAE were asked to classify their requirements into the following categories:

1. *Information or assessment about CAD/CAE applicability to the company.*
2. *Selection, initial implantation and validation of a CAD/CAE solution.*
3. *Training in CAD/CAE.*
4. *Definition or calculation of processes in CAD/CAE.*
5. *Customized development of CAD/CAE software or interfaces.*
6. *Integrate CAD with CAE or both into company processes.*
7. *Other different.*

Taking as a base the 235 companies stating their need for assistance with CAD/CAE, Figure 5-52 shows how these companies are distributed according to their type of requirement. One may observe that 61% of such companies have requirements in the *Information or assessment about the applicability of CAD/CAE to the company* category, and 51% *in CAD/CAE Training.* 20% would be interested in *Selection, initial implantation and validation of a CAD/CAE solution*, while 18% state requirements in *customized development of CAD/CAE software or interfaces*.

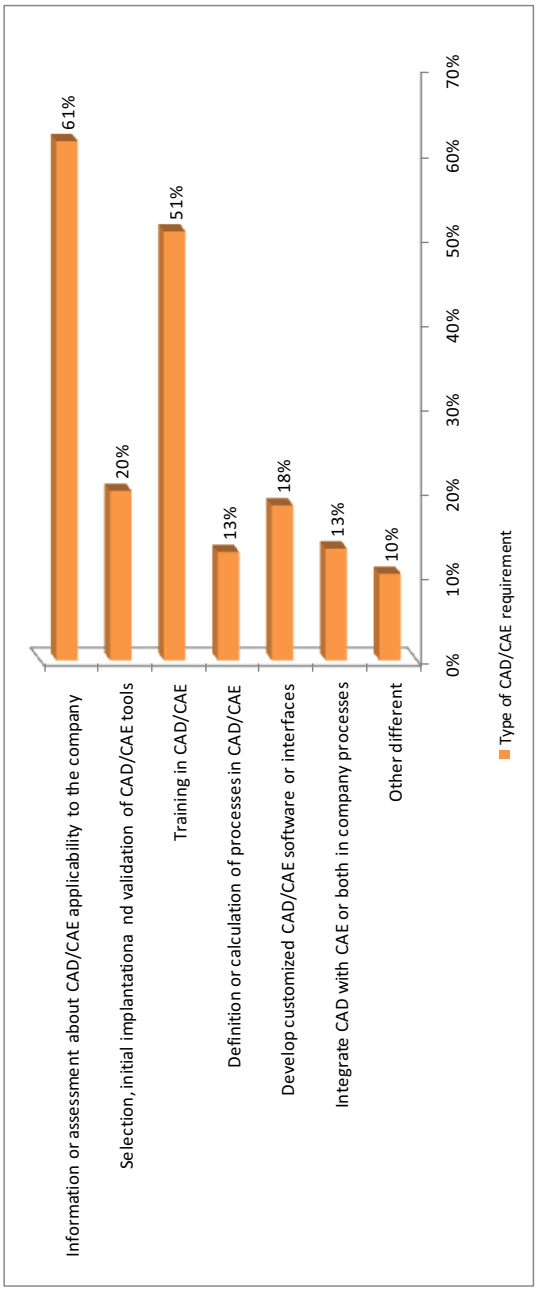


Figure 5-52: Type of CAD/CAE requirement.

By sector

Table 5-11 shows the type of CAD/CAE requirement according to which sectors the companies belong. Thus, for example, of the 8 companies in the Timber and paper sector stating their needs as regards CAD/CAE, 7 indicate that they require *Information or assessment about CAD/CAE applicability to their company* and four that they require *CAD/CAE Training.* In the Health sector, 71% require *Training in CAD/CAE,* while practically half state *Information or assessment, Selection, initial implantation and validation of a CAD/CAE solution* and *customized development of CAD/CAE software or interfaces.* As far as *Integrate CAD with CAE or both into company processes* is concerned, this is most widely requested from companies belonging to the Timber and paper and ICT sectors.

By company size

In the division by company size (see Figure 5-53), and depending on the type of requirement stated, the large companies indicate a greater need than small or medium-sized firms for *Information or assessment about CAD/CAE applicability* and *Selection, initial implantation and validation of a CAD/CAE solution*; as regards the need to *Develop customized CAD/CAE software or interfaces,* there is only a 2% difference between small companies. On the other hand, the need for *Training*, *Integrate CAD with CAE or both* and *Other different* is greater among small and medium-sized companies than among large firms. See Table 5-12.

Sector	Information or assessment	Selection, initial implantation and validation	Training	Definition or calculation of processes	Customized software or interfaces	Integration of CAD with CAE	Others
FOOD (10)	40%	20%	30%	0%	0%	0%	30%
TIM (8)	88%	25%	50%	25%	38%	25%	0%
ENE (25)	56%	12%	40%	16%	24%	16%	16%
MET (42)	60%	21%	62%	12%	10%	19%	7%
CON (33)	70%	18%	52%	3%	9%	3%	3%
COM (16)	75%	13%	38%	6%	19%	13%	6%
TRA (13)	62%	15%	62%	15%	31%	8%	15%
ICT (11)	64%	36%	45%	18%	27%	27%	0%
FIN (11)	55%	18%	36%	18%	18%	9%	18%
HEA (7)	43%	43%	71%	14%	43%	14%	14%
MAN (15)	47%	13%	40%	13%	20%	20%	7%
TEC (31)	61%	29%	65%	26%	29%	13%	6%
MISC (13)	69%	8%	38%	0%	0%	8%	31%
Total (235)	**61%**	**20%**	**51%**	**13%**	**18%**	**13%**	**10%**

Table 5-11: Type of CAD/CAE requirement, by sector (n=235).

Size	Information or assessment	Selection, initial implantation and validation	Training	Definition or calculation of processes	Customized software or interfaces	Integration of CAD with CAE	Others
FROM 10 TO 49 (112)	55%	18%	58%	12%	19%	11%	11%
FROM 50 TO 199 (84)	65%	15%	40%	15%	17%	11%	11%
200 OR MORE (39)	69%	36%	51%	10%	21%	8%	8%
Total (235)	**61%**	**20%**	**51%**	**13%**	**18%**	**13%**	**10%**

Table 5-12: Type of CAD/CAE requirement by company size (n=235).

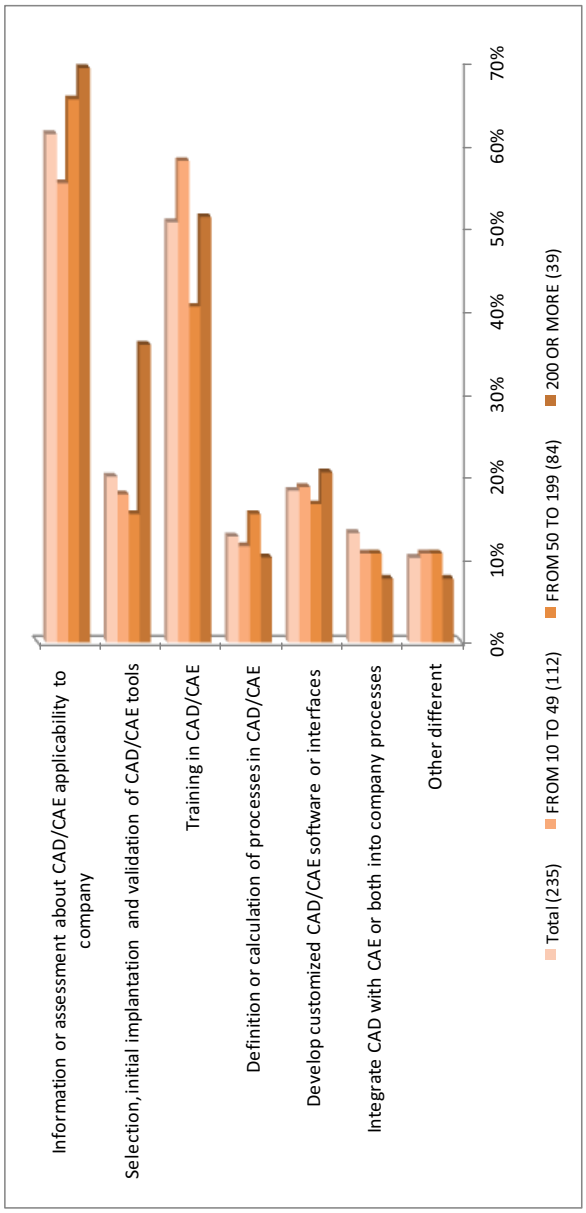


Figure 5-53: Type of CAD/CAE requirement according to company size (n=235).

6 STATISTICS AND OPERATIONS RESEARCH (ST/OR)

6.1 Use of ST/OR

In this section, the diffusion and use of statistical tools and operations research in the business world is analyzed, as well as the assessment and training requirements in this sphere.

From the data obtained in the general sample one observes that practically half the companies state that they use statistical techniques, data analysis techniques or decision-making support techniques in order to conduct, for example, customer analysis, market analysis, and product and quality analysis, as well as for planning, risk evaluation, logistics and the assignation and optimization of resources and processes. See Figure 6-1.

Given that the survey was conducted by phone, and since most of the interlocutors did not belong to the sphere of mathematics, it is possible that the interviewees considered any process deriving from the management of databases as statistical techniques. Note that question C13 in the questionnaire was broadly formulated in reference to the use of *statistical techniques*, *data analysis techniques* or *decision-making support techniques*.

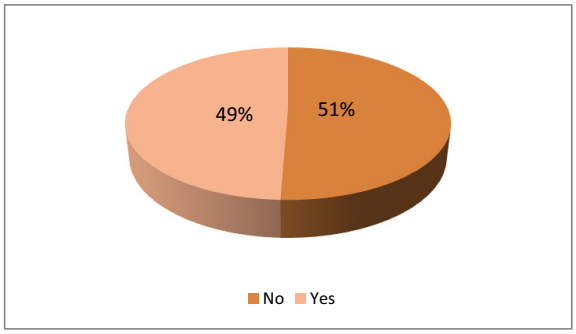
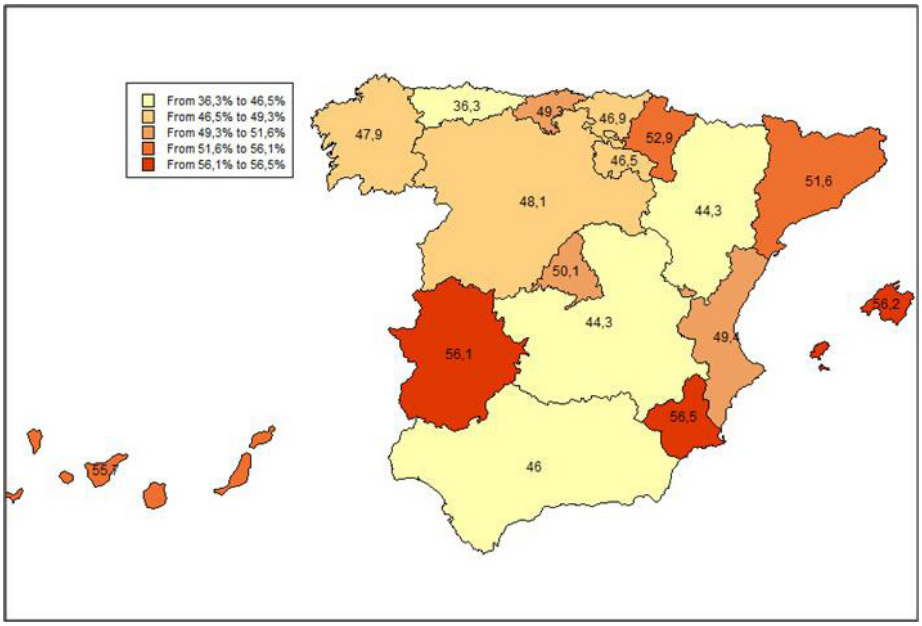


Figure 6-1: Companies using ST/OR (n=6,716).

By Autonomous Community

No appreciable differences are observed when the results are broken down according to autonomous communities, all communities falling between the 45% - 55% range for the use of these tools, with the exception of Asturias (36%). See Map 6-1.



Map 6-1: Companies using ST/OR, by Autonomous Community.

Table 6-1 shows the number of companies in each community that employ some type of tool involving ST/OR.

AUTON. COM.	Use ST/OR	Total Companies
ANDALUCIA	377	820
ARAGON	93	210
ASTURIAS	45	124
BALEARIC ISLANDS	77	137
CANARY ISLANDS	127	228
CANTABRIA	33	67
CASTILLA LA MANCHA	94	212
CASTILLA Y LEON	130	270
CATALUÑA	676	1,310
C. VALENCIANA	350	708
EXTREMADURA	46	82
GALICIA	172	359
MADRID	710	1,418
MURCIA	108	191
NAVARRA	63	119
BASQUE COUNTRY	196	418
LA RIOJA	20	43
Total	**3,317**	**6,716**

Table 6-1: Companies using ST/OR, by Autonomous Community.

By sector

When the sample is segmented according to sector, in Figure 6-2 one observes that the highest percentages of companies using statistical techniques, data analysis techniques or decision-making support techniques are found in the *Commerce* (65%), *Miscellaneous services* (59%) and *Food and clothing* (56%) sectors. The lowest percentage is found in the *Construction* sector, where 33% of companies use these types of techniques.

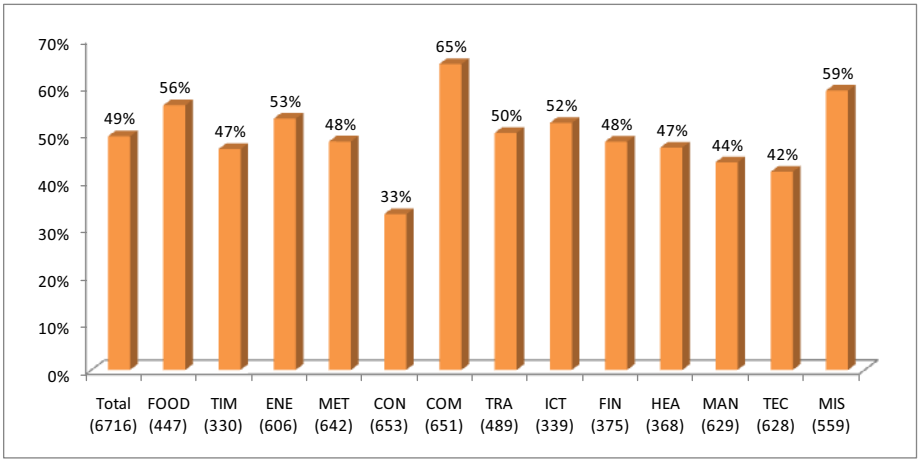


Figure 6-2: Use of ST/OR against the sample total and by sector.

The most noteworthy sector in the distribution of ST/OR user companies (3,317) by sector is again that of *Commerce*, which amounts to 13% of such companies. See Figure 6-3.

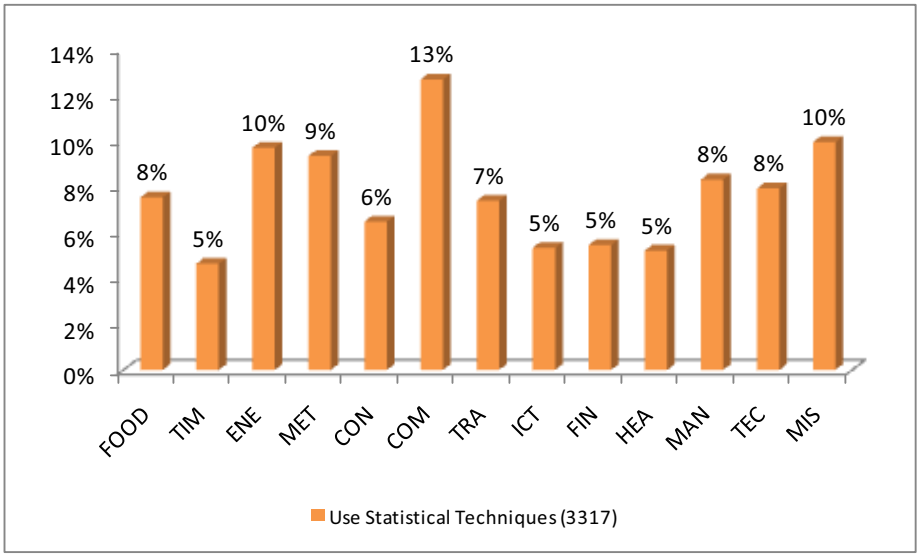


Figure 6-3: Distribution of ST/OR user companies, by sector.

By company size

Next, all the companies in the survey divided according to company size is taken as the base. As expected, the percentage of companies that make use of statistical or operations research tools is highest in the large and medium-size groups rather than in small companies. See Figure 6-4.

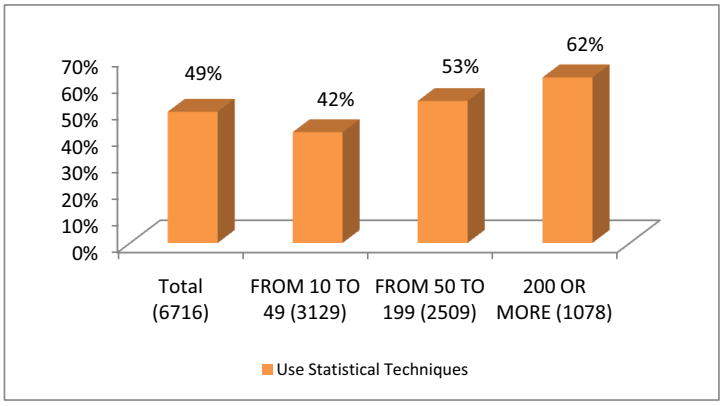


Figure 6-4: Use of ST/OR against sample total, by company size..

If the percentages are now calculated against the total number of ST/OR user companies (3,317), practically 79% of such companies belong to the small and medium-sized categories, from which we may conclude that this fact is conditioned by the internal distribution of the sample, where the number of companies belonging to both categories is much greater than large company category (Figure 6-5).

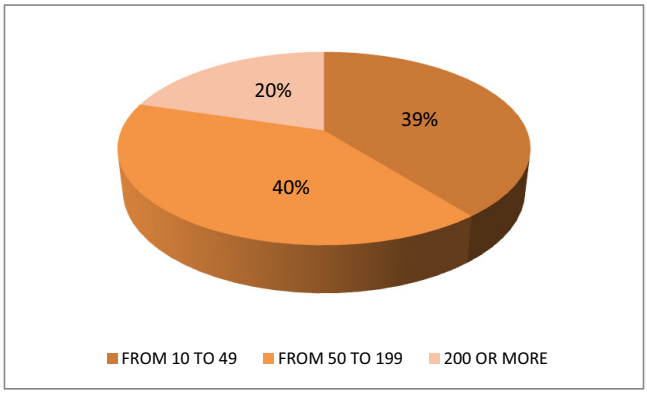


Figure 6-5: Distribution of ST/OR company users by company size (n=3,317).

6.2 Interlocutors in ST/OR

In this section we now analyze what posts are held by those interviewees in the survey belonging to ST/OR user companies. See Figure 6-6. Note that those stating that they are *Responsible for IT*, *Director/manager* and *Others* (*responsible for administration, administrative posts, etc.*) are included in the *Remaining interlocutors* profile.

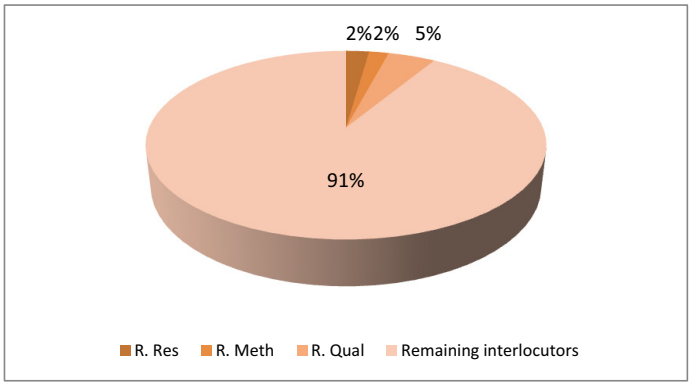


Figure 6-6: Distribution of interlocutors belonging to ST/OR user companies (n=3,317).

It is necessary to point out the high percentage of *Remaining interlocutors* who responded, with only 5% being *Responsible for quality* and 2% of interlocutors being *Responsible for research, development, innovation or engineering,* the same percentage as those *Responsible for methods, schedules, organization and technical department.* Some of these replies should be treated with caution, since the interlocutors well-versed in the areas they were all asked about may well be in a minority.

When the sample is divided into four groups according to the type of interlocutor who responded to the survey, Figure 6-7 shows the percentages for those companies stating that they employed some type of ST/OR. This graph indicates that response may be affected by the post held by the interlocutor within the company: the 49% mean figure of companies stating that they use ST/OR becomes 71% if the interlocutor is *Responsible for quality;* 60% if the reply is *Responsible for research, development, innovation or engineering*, and 59% if the reply is *Responsible for methods, schedules, organization or technical department,* all of them values considerably higher than the mean. Given that only 9% of interlocutors occupy any of the three company posts analyzed, the data included in this document may not faithfully reflect the degree of application of ST/OR carried out in the companies belonging to the survey.

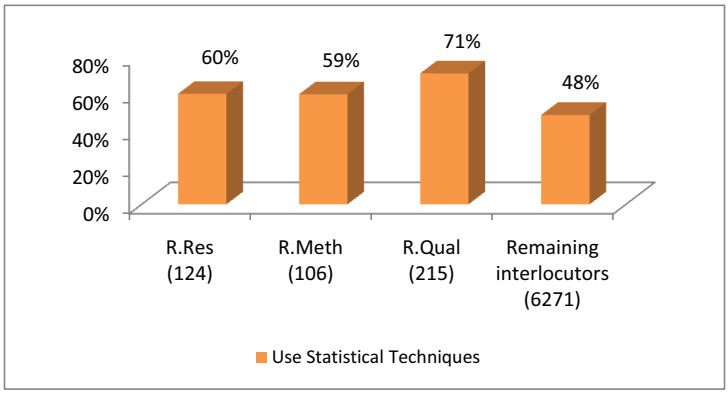


Figure 6-7: ST/OR user companies according to type of interlocutor.

By sector

When the overall result is compared with that of each sector, no appreciable differences are found in terms of who responded to the survey. Virtually 90% of interlocutors in each of the sectors belong to the afore-mentioned *Remaining interlocutors* profile. It is worth pointing out the 15% of interlocutors belonging to the *Responsible for research, development, innovation or engineering; Responsible for methods, schedules, organization or technical department* and *Responsible for quality* profiles in the *Technical services* sector, a percentage that becomes 14% in the *Metal and machinery* sector; both values being well above the 9% mean. See Figure 6-8, where the type of interlocutor corresponds only to *Responsible for research, development, innovation or engineering, Responsible for methods, schedules, organization and technical department* and *Responsible for quality* profiles.

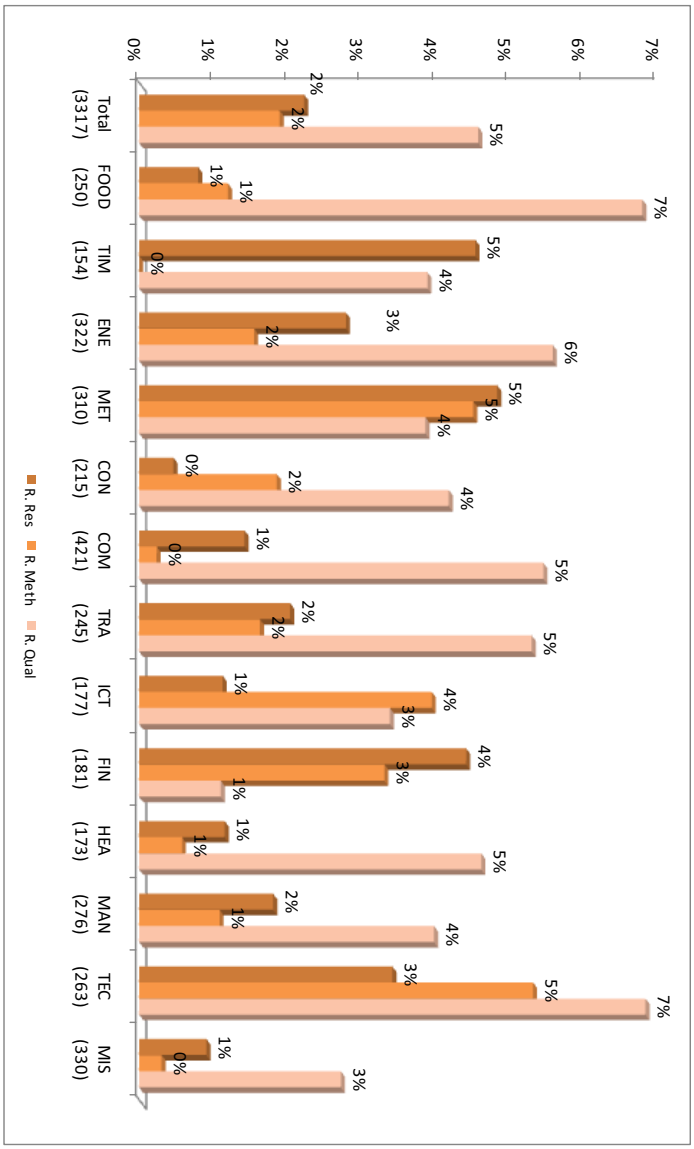


Figure 6-8: Analysis of interlocutors belonging to ST/OR user companies, by sector.

6.3 How ST/OR are used

From among the companies using ST/OR tools, in this section those that employ such tools internally within the company, externally or both are analyzed.

In Figure 6-9 one may observe that 94% of companies apply ST/OR internally, with only 5% of the total number of companies using such techniques externally on an exclusive basis.

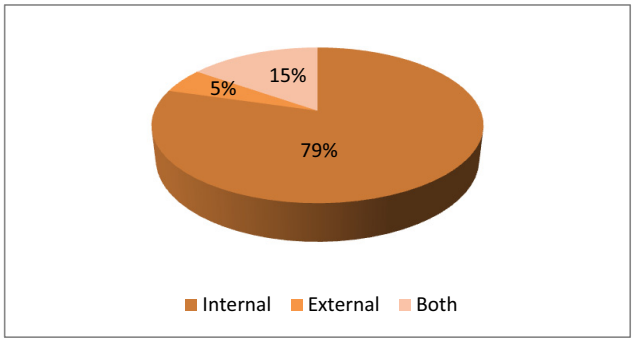


Figure 6-9: Companies that use ST/OR, according to type of use (n=3,317).

By sector

In the division by sector, almost 100% of the companies engaged in *Timber and paper* and *Health* activities employ ST/OR tools internally, while only 1% and 2% of such companies, respectively, use them exclusively externally. See Figure 6-10.

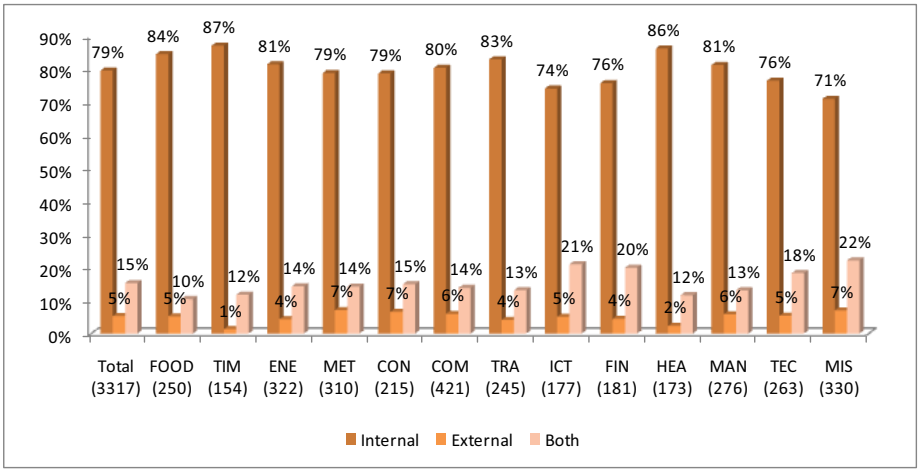


Figure 6-10: ST/OR user companies according to type of use by sector.

By company size

Comparison according to company size shows that large companies are those that make least use of ST/OR only externally, with a figure of 3%, a behavior that is analogous with the use of CAE. See Figure 6-11. It should be noted that these differences are not statistically significant.

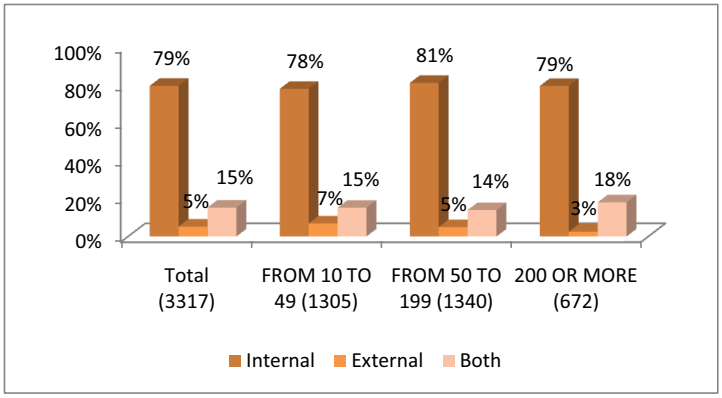


Figure 6-11: Companies that employ ST/OR according to type of use, by company size.

6.3.1 Type of software internally employed in the application of ST/OR.

This section deals with those companies that make use of ST/OR internally, with a study of the type of software employed according to whether it is commercial, free or of both types.

Of the 3,143 companies using ST/OR internally, 74% employ commercially available software, while 20% employ free software on an exclusive basis. See Figure 6-12.

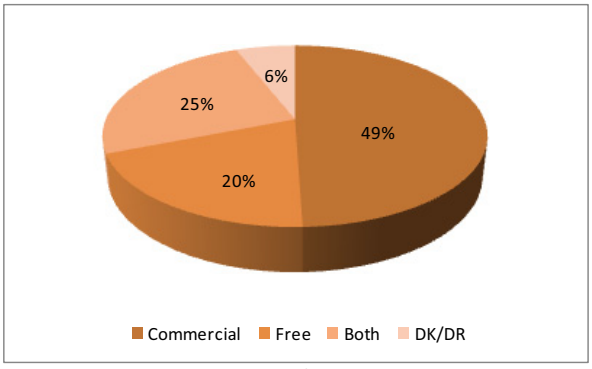


Figure 6-12: Companies employing ST/OR internally according to type of software used (n=3,143).

By sector

Table 6-2 shows that the exclusive use of free software decreases by almost 10% in comparison with the sample total in the *Metal and machinery* sector (11%), a percentage that reaches its highest value in the *Health* sector (25%). Where the companies that gave their reply as *both* are concerned, the sectors with the highest percentages are *Technical services* and *ICT*, with 52%, followed by *Construction*, with a figure of 50% of companies employing free software for ST/OR. See Figure 6-13.

Sector	Commercial	Free	Both	DK/DR
FOOD (237)	56%	19%	18%	7%
TIM (152)	53%	22%	24%	1%
ENE (308)	48%	23%	24%	5%
MET (288)	57%	11%	24%	8%
CON (201)	44%	19%	31%	5%
COM (396)	51%	19%	25%	5%
TRA (235)	48%	22%	23%	7%
ICT (168)	41%	23%	29%	7%
FIN (173)	40%	20%	27%	13%
HEA (169)	47%	25%	22%	5%
MAN (260)	51%	20%	26%	3%
TEC (249)	42%	19%	33%	6%
MIS (307)	56%	18%	21%	6%
Total (3,143)	**49%**	**20%**	**25%**	**6%**

Table 6-2: Companies using ST/OR internally, according to type of software used by sector.

The following graph shows the percentages for companies stating that they used free software or both types.

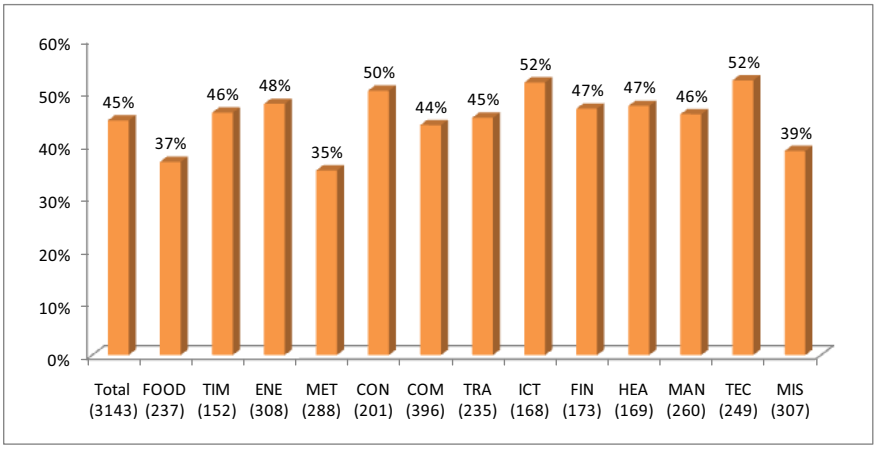


Figure 6-13: Companies using ST/OR internally that employ free software (n=3,143).

By company size

In the analysis according to company size, no significant differences are found as regards the type of software employed. See Figure 6-14.

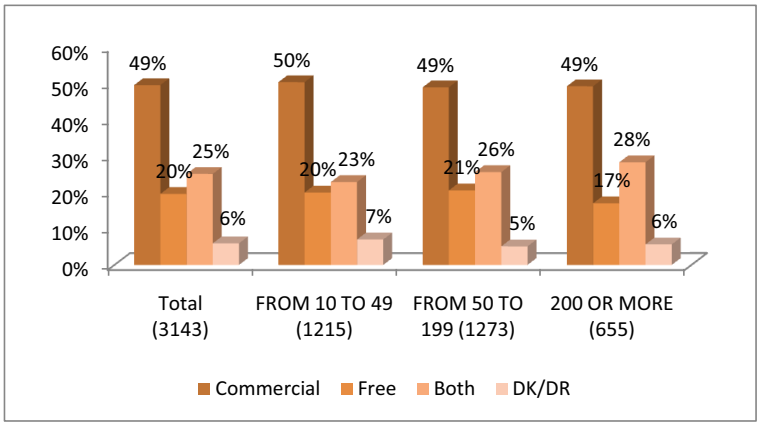


Figure 6-14: Companies that use ST/OR internally, according to type of software used and by company size.

6.3.2 Internal use of ST/OR and with customized ST/OR programs or modules

Figure 6-15 shows that 71% of the companies that employ ST/OR internally make use of customized programs or modules.

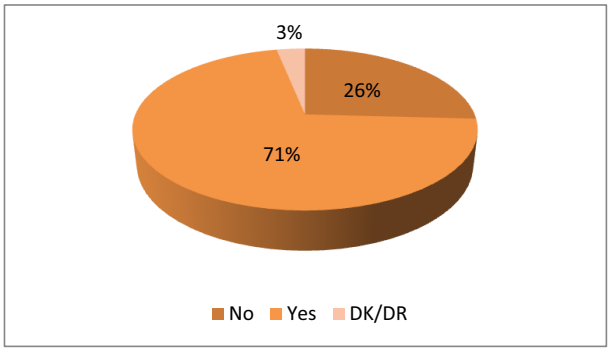


Figure 6-15: Companies employing ST/OR internally, according whether they have customized ST/OR programs or modules (n=3,143).

By sector

When compared by sector, this figure of 71% of the sample total falls to 60% in the *Metal and machinery* sector, and to 65% in the *Construction* and *Technical services* sectors, but increases in the *Commerce*, *Transport and storage* and *Finance* sectors, all of them with 77%, followed by the *Timber and paper* sector with 76%. See Figure 6-16.

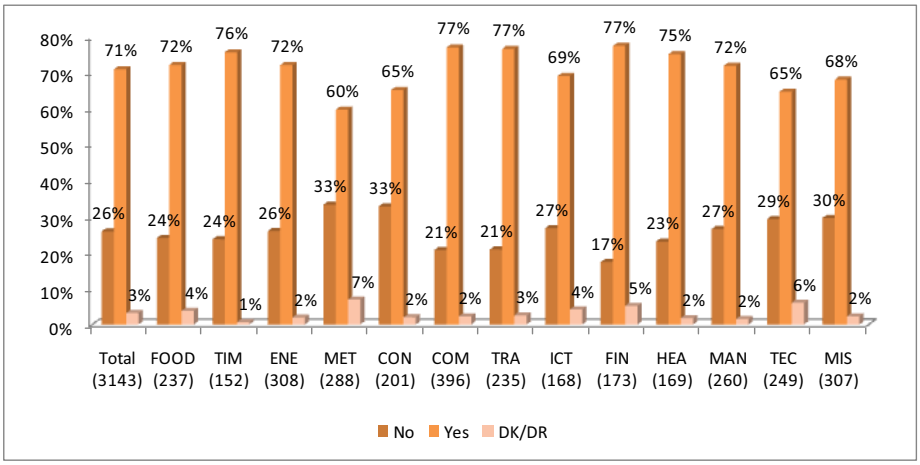


Figure 6-16: Companies employing ST/OR internally, according to whether they use customized ST/OR programs or modules, by sector.

By company size

In the analysis by company size, the companies that make least use of customized programs or modules are those with the smallest workforces. See Figure 6-17.

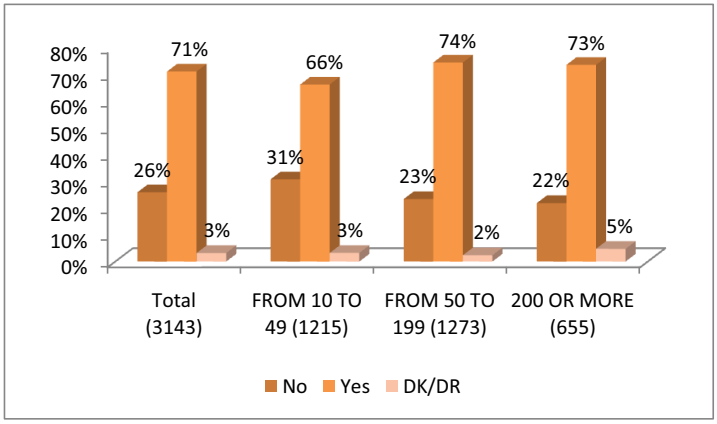


Figure 6-17: Companies employing ST/OR internally, according to whether they have customized ST/OR programs or modules, by company size.

6.4 Areas of ST/OR application

Question C15 in the questionnaire referred to what type of subjects or areas were statistical techniques, data analysis techniques or decision-making support techniques applied. The possible answers to this question are detailed below:

1. *Quality control.*
2. *Control and optimization of stocks.*
3. *Control and optimization of production processes.*
4. *Analysis of risk or financial products.*
5. *Strategy, decision-making, logistics and planning.*
6. *Customer analysis and market and product studies.*
7. *Exploitation of internal information (data mining, business intelligence).*
8. *Others (e.g., experimental design, clinical analyses, etc.).*

Of all the companies stating that they used ST/OR in the course of their work (3,317), it transpires that 66% apply these tools to de *Customer analysis and market or product studies*. A somewhat lower percentage, 48%, apply these tools to *Quality control*, and 43% to *Strategy, decision-making, logistics and planning*. See Figure 6-18. It should be noted that since Question C15 admits multiple answers, the same company may indicate applications in several different areas or subjects.

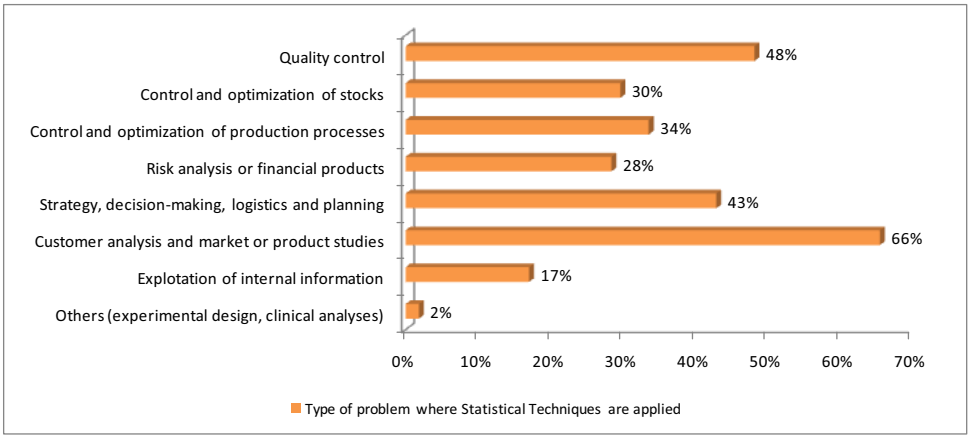


Figure 6-18: Areas where ST/OR are applied by companies in the sample (n=3,317).

By sector

Table 6-3 shows the data on the type of ST/OR use according to sector of activity. The most noteworthy is the application to *Customer analysis and market and product studies* in the sectors of *Miscellaneous services* (78%), *Information and communication technologies* (73%), *Finance* (71%), *Management services* (71%) and *Food and clothing* (69%), all with values above the sample total mean, which is 66%. In the remaining types of application of these tools, only the area of Quality control in the sectors of *Metal and machinery* (65%) and *Energy, chemical and environment* (61%) is greater than 60%. It is worth pointing out that in the field of Health only half the companies stated that they use some type of *Quality control* technique.

Sector	*Quality control*	*Control and optimization of stocks*	*Control and optimization of production processes*	*Risk analysis or financial products*	*Strategy, decision-making, logistics and planning*	*Customer analysis and market studies*	*Exploitation of internal information*	*Others (experimental design, clinical analyses)*
FOOD (250)	59%	46%	50%	28%	37%	69%	15%	1%
TIM (154)	52%	33%	44%	27%	42%	66%	16%	1%
ENE (322)	61%	35%	41%	31%	39%	60%	17%	1%
MET (310)	65%	43%	55%	31%	41%	57%	17%	1%
CON (215)	58%	31%	39%	40%	47%	61%	19%	0%
COM (421)	47%	42%	28%	28%	46%	67%	18%	2%
TRA (245)	44%	24%	26%	28%	58%	61%	19%	0%
ICT (177)	37%	20%	33%	21%	40%	73%	18%	2%
FIN (181)	27%	8%	17%	49%	41%	71%	17%	1%
HEA (173)	50%	16%	12%	20%	31%	58%	21%	13%
MAN (276)	38%	21%	29%	28%	38%	71%	17%	2%
TEC (263)	43%	16%	32%	26%	41%	60%	17%	3%
MIS (330)	39%	28%	25%	19%	50%	78%	13%	1%
Total (3,317)	**48%**	**30%**	**34%**	**28%**	**43%**	**66%**	**17%**	**2%**

Table 6-3: Fields in which ST/OR tools are applied in the sample total, by sector (n=3,317).

By company size

As regards the number of employees in each company, in general one may say the larger the company the greater the use of ST/OR tools. The fields of *Quality control*, *Control and optimization of production processes* and *Strategy, decision-making, logistics and planning* show an approximately 10% difference on the side of large companies. No appreciable difference is found in *Customer analysis and market studies*, where more than 60% of small companies state that they apply such techniques. See Figure 6-19 and Table 6-4.

Company size	*Quality control*	*Control and optimization of stocks*	*Control and optimization of production processes*	*Risk analysis or financial products*	*Strategy, decision-making, logistics and planning*	*Customer analysis and market studies*	*Exploitation of internal information*	*Others (experimental design, clinical analyses)*
FROM 10 TO 49 (1,305)	43%	24%	30%	26%	39%	63%	16%	2%
FROM 50 TO 199 (1,340)	50%	32%	34%	27%	44%	67%	16%	2%
200 OR MORE (672)	56%	35%	40%	35%	49%	67%	22%	2%
Total (3,317)	**48%**	**30%**	**34%**	**28%**	**43%**	**66%**	**17%**	**2%**

Table 6-4: Types of application of ST/OR tools against the sample total, by company size (n=3,317).

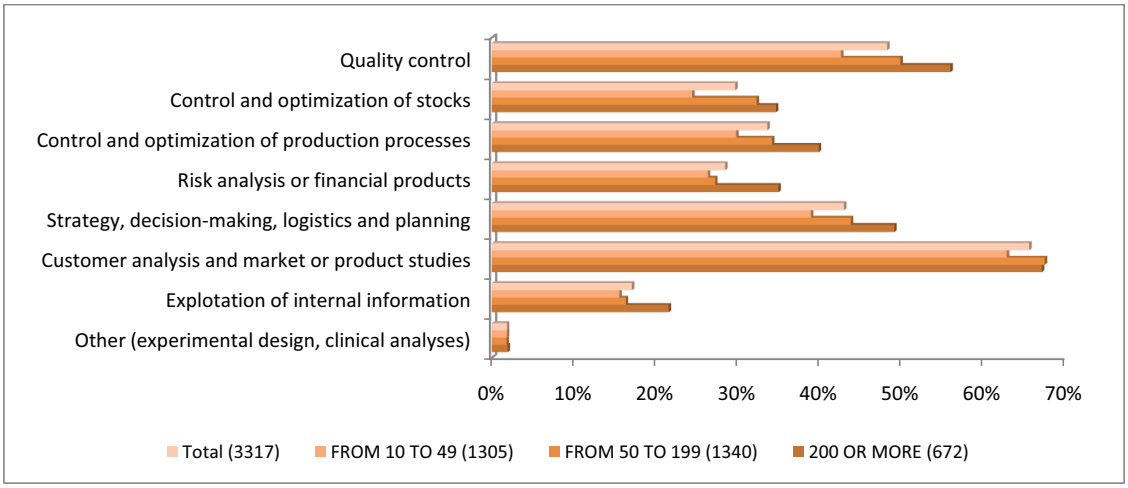


Figure 6-19: Companies with ST/OR requirements (n=6,716).

6.5 Requirements in ST/OR

Of all the companies in the survey, 7% stated that they had some requirement in statistics, data analysis or decision-making support. This amounts to 461 companies among those belonging to the sample. See Figure 6-20.

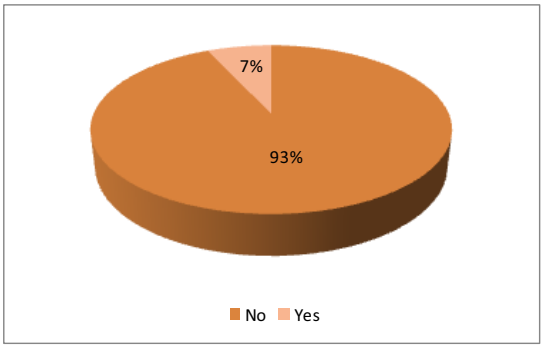


Figure 6-20: Companies with ST/OR requirements (n=6,716).

By sector

If these percentages are calculated against the total number of companies in each sector, the *Miscellaneous services* sector with 11% is that with the greatest requirement in these types of tools. See Figure 6-21.

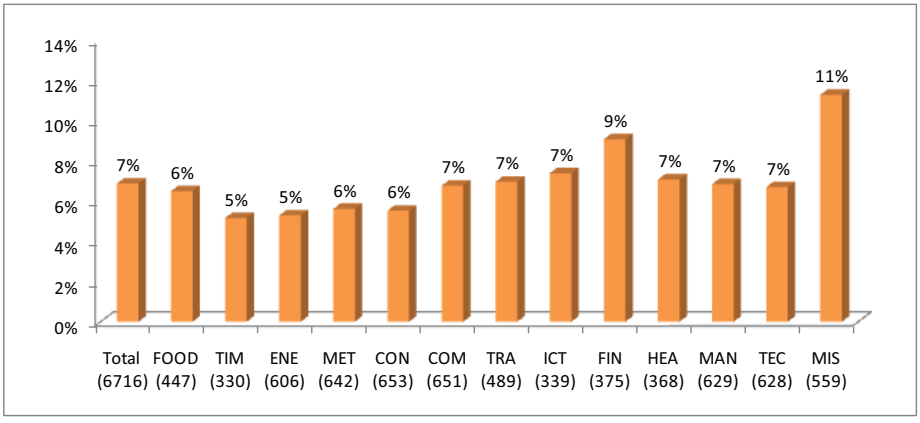


Figure 6-21: Companies in the sample total with ST/OR requirements, by sector.

Of the 461 companies with some type of requirement, 14% belong to *Miscellaneous services* and 10% to *Commerce*. Figure 6-22 shows the distribution by sector.

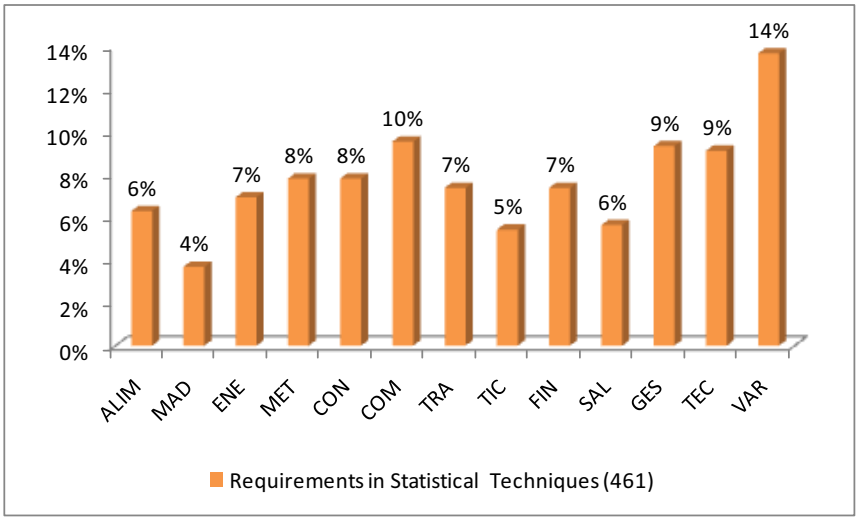


Figure 6-22: Distribution of companies with ST/OR requirements, by sector.

By company size

If the comparison is now made according to company size, this value increases slightly in those companies with more than 199 employees, with a figure of 9%, which would be equivalent to 97 companies from the sample total. See Figure 6-23.

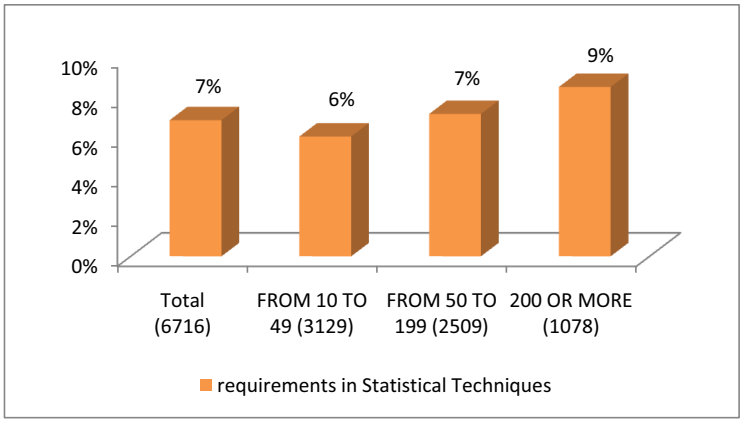


Figure 6-23: Companies in the sample total with ST/OR requirements, by company size.

Following the same procedure as in previous sections, Figure 6-24 shows the distribution by company size of those firms stating that they have some requirement in statistics, data analysis or decision-making support.

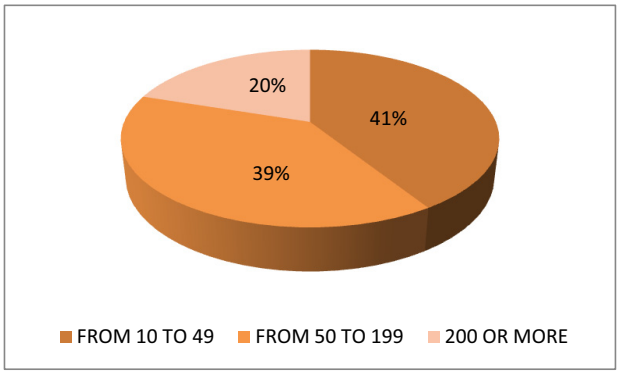


Figure 6-24: Distribution of companies with ST/OR requirements by company size (n= 461).

6.5.1 Type of ST/OR requirements

Question C19 in the questionnaire referred to the classification of ST/OR needs and requirements as follows:

1. *Training.*
2. *Quality control.*
3. *Control and optimization of stocks.*
4. *Control and optimization of production processes.*
5. *Risk analysis or financial products.*
6. *Strategy, decision-making, logistics and planning.*
7. *Customer analysis and market or product studies.*
8. *Exploitation of internal information (data mining, business intelligence).*
9. *Others; for example, experimental design, clinical analyses,etc..*

The most frequently requested needs were found in the areas of *Customer analysis and market or product studies* (40%), *Training* (39%), *Strategy, decision-making, logistics and planning* (36%) and *Quality control* (30%), which in general coincide with the most widely used techniques, as seen in the previous sector. See Figure 6-25.

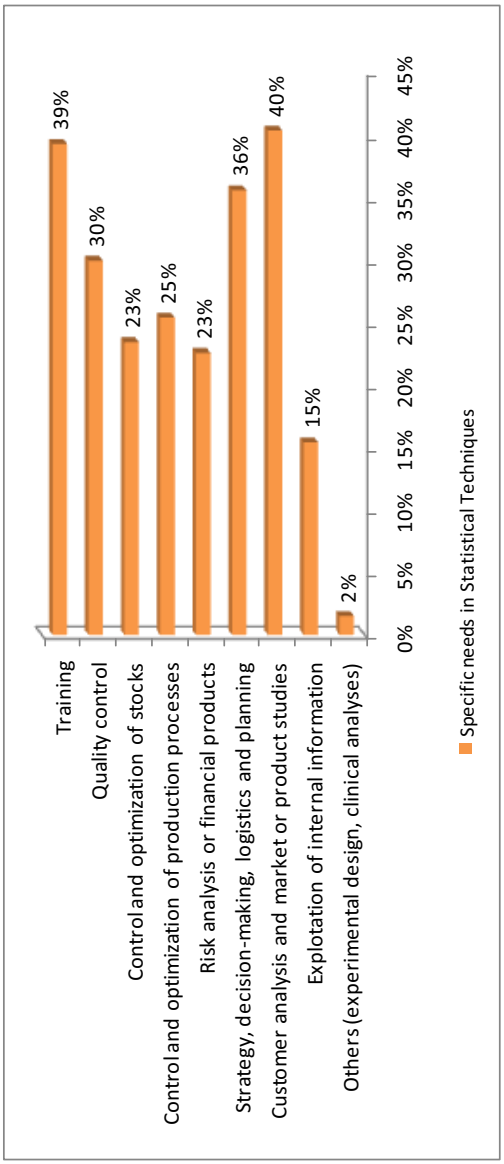


Figure 6-25: Types of ST/OR requirements (n=461)

By sector

In the analysis by type of requirement, differences are found according to whether a company belongs to either one sector or another. Thus, in more than 50% of cases companies in the *Food and clothing, Energy, chemical and environment* sectors stated their need for *Quality control* processes, a percentage considerably higher than the 30% mean for the sample total. In particular, the *Food and clothing* and *Timber and paper* sectors evinced above average requirements for ST/OR tools in practically all the areas of application. See Table 6-5.

Sector	*Training*	*Quality control*	*Control and optimization of stocks*	*Control and optimization of production processes*	*Risk analysis or financial products*	*Strategy, decision-making, logistics and planning*	*Customer analysis and market studies*	*Exploitation of internal information*	*Others (experimental design, clinical analyses)*
FOOD (29)	41%	52%	48%	41%	21%	38%	45%	17%	3%
TIM (17)	41%	47%	35%	41%	47%	53%	41%	35%	0%
ENE (32)	50%	53%	38%	28%	22%	25%	47%	28%	6%
MET (36)	44%	28%	19%	36%	19%	25%	31%	11%	0%
CON (36)	33%	28%	36%	33%	22%	25%	44%	17%	0%
COM (44)	45%	30%	36%	27%	25%	39%	55%	14%	0%
TRA (34)	35%	35%	12%	26%	24%	44%	26%	18%	3%
ICT (25)	44%	16%	16%	28%	20%	32%	36%	8%	0%
FIN (34)	21%	18%	6%	15%	53%	15%	38%	9%	0%
HEA (26)	46%	46%	19%	19%	8%	19%	31%	23%	8%
MAN (43)	40%	26%	23%	14%	26%	40%	51%	16%	0%
TEC (42)	57%	24%	21%	29%	17%	29%	50%	14%	2%
MIS (63)	24%	16%	10%	13%	10%	62%	29%	8%	0%
Total (461)	39%	30%	23%	25%	23%	36%	40%	15%	2%

Table 6-5: Type of ST/OR requirements by sector (n=461).

By company size

As regards division by company size, differences are found in the different requirements for statistical or operations research tools. If larger companies are compared with smaller companies, the greatest difference is observed in *Control and optimization of product processes*, with values of 19% and 36% respectively for firms stating their need for assistance in this area. See Figure 6-26 y Tabla 6-6.

Company size	*Training*	*Quality control*	*Control and optimization of stocks*	*Control and optimization of production processes*	*Risk analysis or financial products*	*Strategy, decision-making, logistics and planning*	*Customer analysis and market studies*	*Exploitation of internal information*	*Others (experimental design, clinical analyses)*
FROM 10 TO 49 (189)	35%	24%	16%	19%	19%	35%	37%	14%	1%
FROM 50 TO 199 (180)	42%	35%	30%	27%	25%	37%	43%	18%	2%
200 OR MORE (92)	43%	33%	25%	36%	25%	34%	43%	13%	2%
Total (461)	**39%**	**30%**	**23%**	**25%**	**23%**	**36%**	**40%**	**15%**	**2%**

Tabla 6-6:Type of ST/OR requirements by company size (n=461).

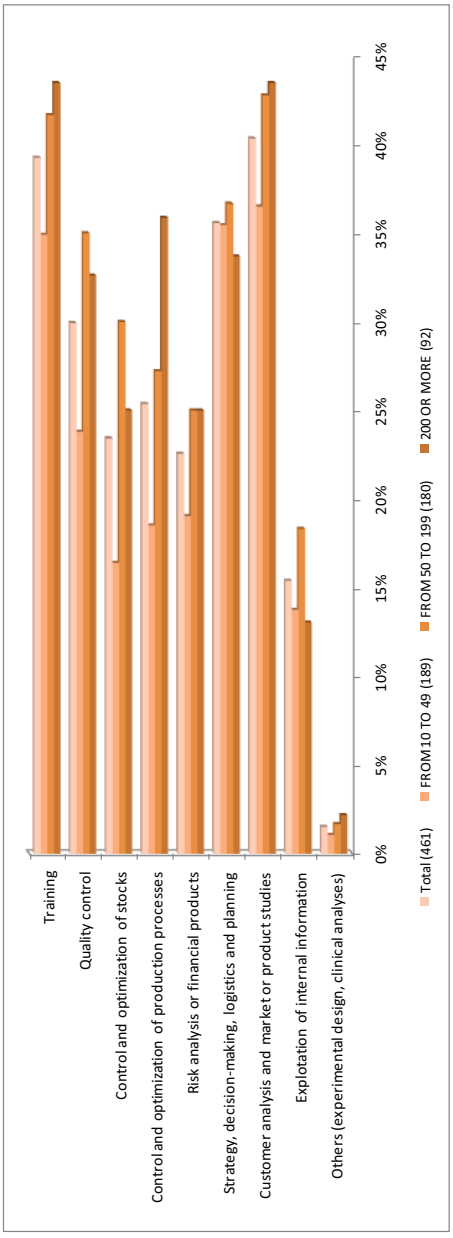


Figure 6-26: Type of ST/OR requirements by company size (n=461).

7 OTHER MATHEMATICAL TECHNIQUES (OMT)

7.1 Use of OMT

In this section we analyze those companies which stated that they applied, either externally or internally, OMT different from those already addressed in the questionnaire. These techniques include geographical tracking, digital image or signal processing; geometry, design or visualization; bio-informatics or bio-mathematics; search and codification of information, or computation.

The sector graph in Figure 7-1 shows that 8% of the 6,716 companies making up the sample apply OMT in some of the areas previously dealt with. This amounts to a total of 542 companies that make use of OMT.

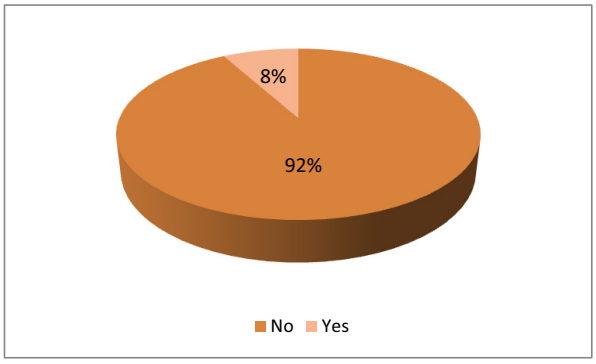
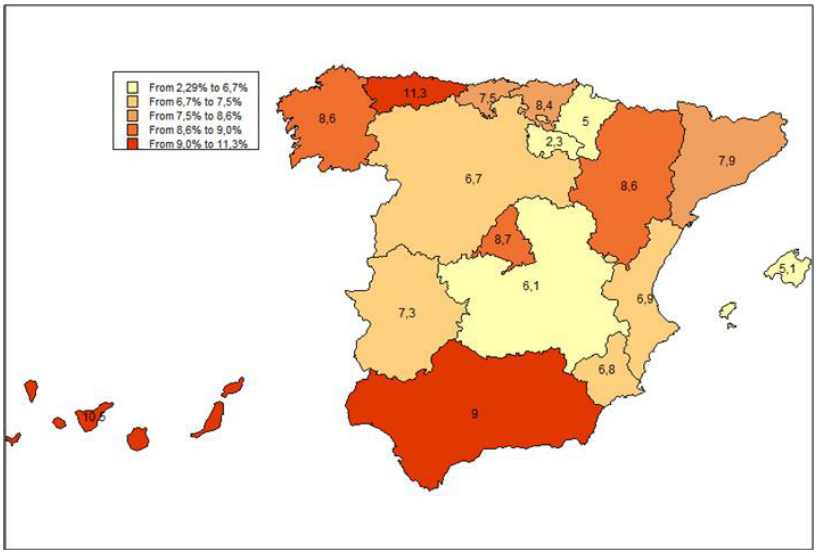


Figure 7-1: Companies using OMT (n=6,716).

By Autonomous Community

In the analysis by Autonomous Community, the highest percentages are found in Asturias (11.3%) and the Canary Islands (10.5%). See Map 7-1.



Map 7-1: Companies using OMT (n=6,716).

Tabla 7-1 shows the sample sizes of each autonomous community and the number of companies from among those interviewed in each community that apply OMT. In absolute terms, it is worth pointing out that 124 companies in Madrid and 104 in Cataluña make use of OMT.

AUT. COM.	Use OMT	Total companies
ANDALUCIA	74	820
ARAGON	18	210
ASTURIAS	14	124
BALEARIC ISLANDS	7	137
CANARY ISLANDS	24	228
CANTABRIA	5	67
CASTILLA LA MANCHA	13	212
CASTILLA Y LEON	18	270
CATALUÑA	104	1,310
C. VALENCIANA	49	708
EXTREMADURA	6	82
GALICIA	31	359
MADRID	124	1,418
MURCIA	13	191
NAVARRA	6	119
BASQUE COUNTRY	35	418
LA RIOJA	1	43
Total	**542**	**6,716**

Tabla 7-1: Companies using OMT, by Autonomous Community.

By sector

Figure 7-2 shows that differences exist according to which sector the company belongs. Thus, the lowest percentages of OMT use (4%) are found in the *Food and clothing* sector, while the highest percentages for the most frequent use of these techniques are found in the *ICT and Technical services* and *Transport and storage* sectors, with 16% an 13%, respectively.

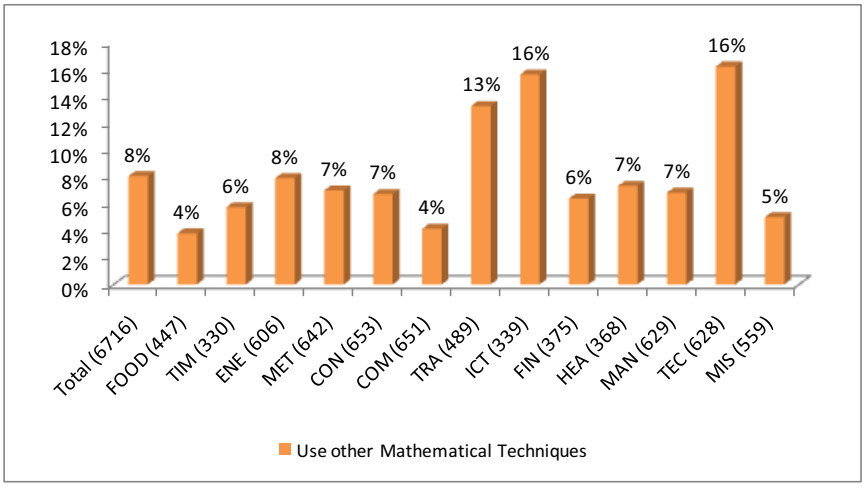


Figure 7-2: Companies using OMT against the sample total, by sector.

Distribution by sector of the 542 companies that use OMT is shown in Figure 7-3. The highest percentages are still found in the *Technical services* (19%), *Transport and storage* (12%) and *ICT* (10%) sectors.

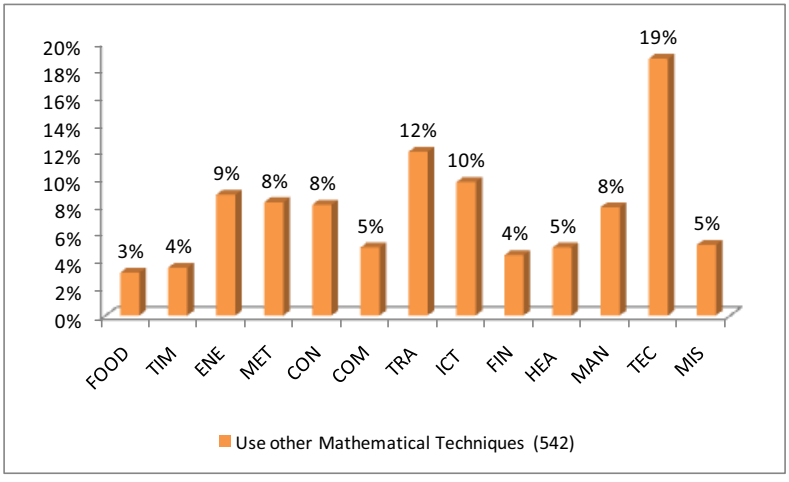


Figure 7-3: Distribution of OMT user companies by sector.

By company size

As expected, the larger the company the more they employ OMT in their tasks, with figures of 6% for small companies and 13% in large companies. See Figure 7-4.

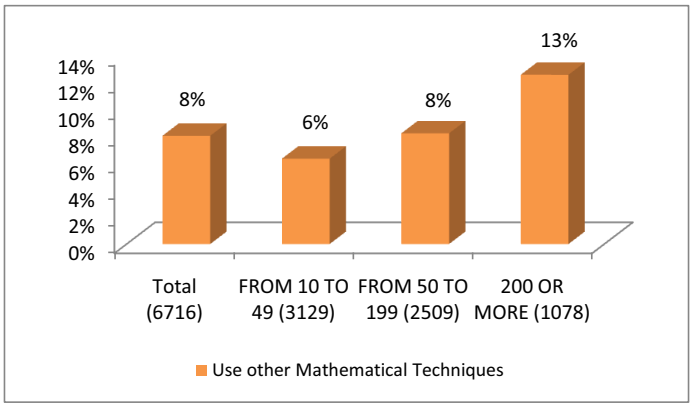


Figure 7-4: Companies using OMT against the sample total, by company size.

Once again, due to the nature of the sample itself, in the distribution according to company size of those companies that use OMT, 75% of the 542 firms in the sample are either small or medium-sized companies, as shown in Figure 7-5.

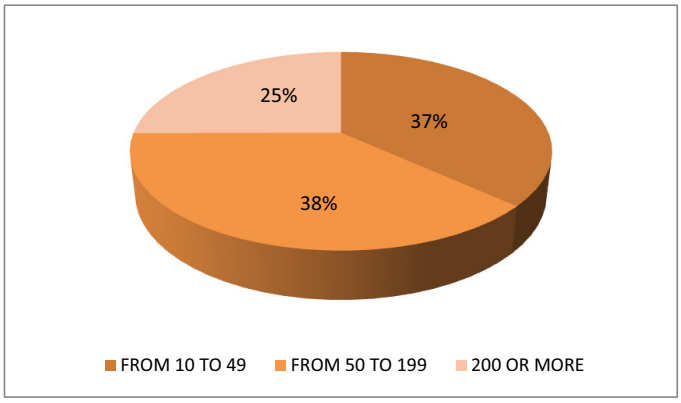


Figure 7-5: Distribution of OMT user companies according to company size (n=542).

7.2 Interlocutors in OMT

The posts held by interlocutors who responded to the survey and stated that they use OMT are now analyzed. This distribution is shown in Figure 7-6. Note that those *Responsible for IT*, *Director/manager and Others (responsible for administration, administrative posts, etc.)* are included in the *Remaining interlocutors* profile.

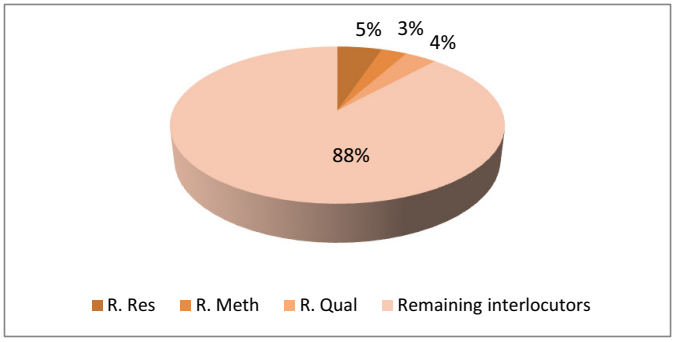


Figure 7-6: Distribution of interlocutors belonging to OMT user companies (n=542).

88% of the interviewees belonging to these companies correspond to the *Remaining interlocutors* profile. Those stating they were *Responsible for research, development, innovation or engineering* yielded a figure of 5%; those *Responsible for methods, schedules, organization or technical department* 3%, and those *Responsible for Quality* one percent higher at 4%.

When the sample is divided into four groups according to the type of interlocutor who responded to the survey, Figure 7-7 shows the percentages of those companies stating that they use OMT according to the interviewee belonging to that company. Thus, in 23% of companies the person answering the questions stated that he or she was *Responsible for research, development, innovation or engineering* and that OMT was used, while in 15% interviewees said that they were *Responsible for methods, schedules, organization or technical department*, and in 9% that they were *Responsible for Quality.* The lowest value of 8% corresponds to the *Remaining interlocutors* profile.

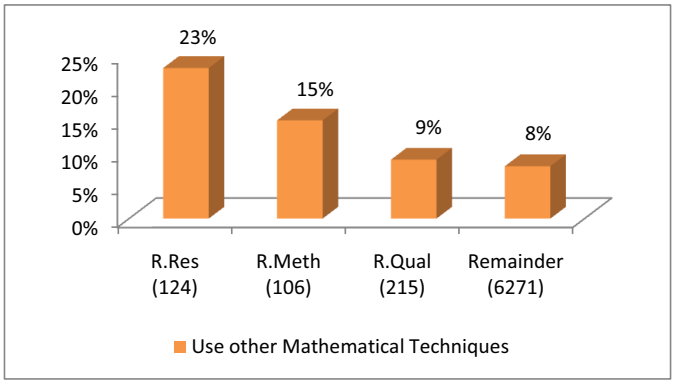


Figure 7-7: Companies that use OMT according to type of interlocutor.

Table 7-2 gives the percentages of the previous graph in absolute terms of the total and by sector.

Sector	R. Inv	R. Met	R. Qual	Remaining	Use OMT
01.-FOOD	1		2	14	17
02.-TIM	1			18	19
03.-ENE	4	2	2	40	48
04.-MET	8	3	1	33	45
05.-CON		2	2	40	44
06.-COM	1		1	25	27
07.-TRA	4		4	57	65
08.-ICT	2	4	2	45	53
09.-FIN		2		22	24
10.-HEA	3		1	23	27
11.-MAN		1		42	43
12.-TEC	4	2	5	91	102
13.-MIS				28	28
Total	**28**	**16**	**20**	**478**	**542**

Table 7-2: Number of interlocutors in OMT user companies, by sector.

By sector

When in the analysis of interlocutors the overall result (Figure 7-6) is compared with that of each sector, no appreciable differences are observed as regards the person who responded to the survey. In each sector, between 80% and 90% of the interviewees belong to the Remaining interlocutors profile. It is worth pointing out the 18% and 11% of interlocutors belonging to the *Responsible for research, development, innovation or engineering* profile in the *Metal and machinery* and *Health* sectors, respectively, and the 12% belonging to the *Responsible for Quality* profile in the *Food and clothing* sector. See Figure 7-8.

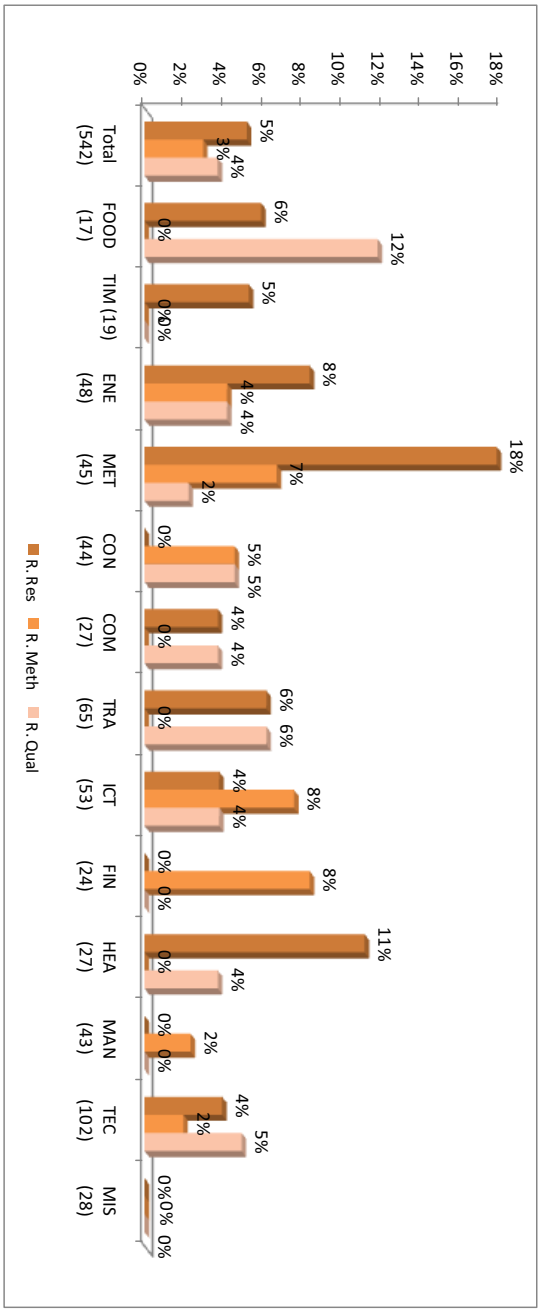


Figure 7-8: Analysis of interlocutors belonging to OMT user companies, by sector.

7.3 Type of applications used in OMT

Question C22 in the questionnaire referred to what type of fields OMT were applied in companies using these techniques. The possible replies to this question are detailed below:

1. *Digital images: graphs, video, animation, image recognition.*
2. *Geometric analysis: computational geometry, visualization, CAD development, symbolic methods.*
3. *Digital signal processing.*
4. *Design of geographical tracking systems such as GIS or GPS.*
5. *Communication networks.*
6. *Codification of information, cryptography, computer security.*
7. *Computation, computational algebra, language processing, numerical-symbolic algorithms.*
8. *Search and processing of information and knowledge: semantic web, algorithms for the internet.*
9. *Bio-informatics, genomics and proteomics.*
10. *Bio-mathematics: applications to life sciences and health (such as diagnostic techniques, medical prescriptions, drug administration, tumor growth and propagation, pest control, systems biology).*
11. *Others.*

Of all the companies which replied that they used OMT in the course of their work (542), 48% made use of these tools in applications to *Digital image* processing. A slightly lower percentage (39%) stated that they were used in areas associated with *Design of geographical tracking systems such as GIS or GPS,* while somewhat fewer but with practically the same percentage stated that they were applied to *Geometric analysis* (24%) and *Communication networks* (25%). Note that, since various answers were possible in reply to Question C22, different areas of application may occur within the same company. See Figure 7-9.

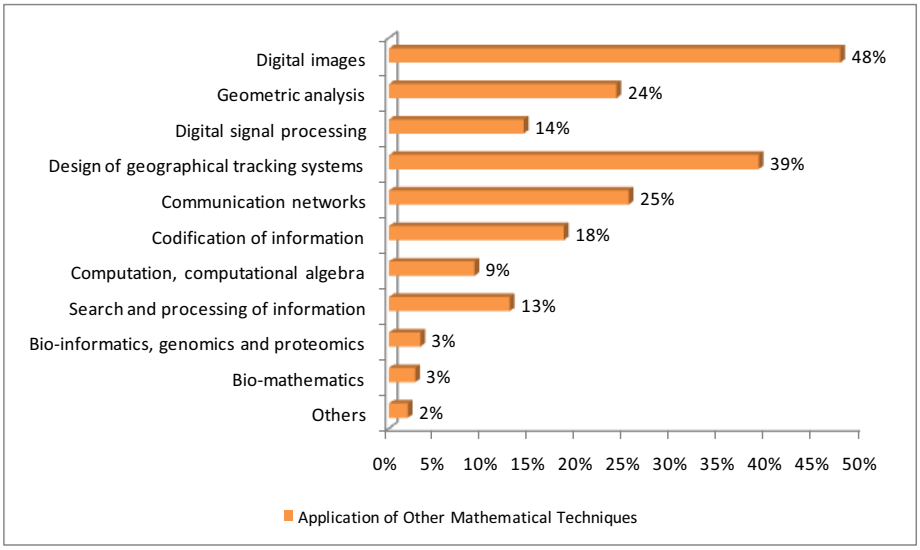


Figure 7-9: Areas of application in OMT user companies (n=542).

By sector

Table 7-3 shows the analysis by sector of the areas of application in OMT user companies. The highest percentages in all the sectors correspond to *Digital image* processing, with above 60% in *Timber and paper* and *ICT*, and below 39% only in *Food and clothing*, *Transport and storage*, *Finance* and *Management services*. As regards applications in *Geometric analysis*, the most noteworthy are *Construction* and *Metal and machinery* with 52% and 47%, respectively. As expected, in applications to *Design of geographical tracking systems such as GIS or GPS,* the *Transport and storage* sector has the highest values with 75% among OMT user companies. Techniques associated with *Codification of information, cryptography, computer security* and *Communications Networks* are used in almost half the financial companies stating that they use OMT. The remaining mathematical techniques detailed in the section above are the object of a more minority use.

Sector	Digital images	Geometric analysis	Digital signal processing	GIS or GPS	Communication Networks	Codification, cryptography	Computation, computational algebra	Information search and processing	Bio-informatics, genomics and proteomics	Bio-mathematics	Others
FOOD (17)	35%	18%	18%	35%	35%	18%	18%	12%	6%	12%	0%
TIM (19)	63%	16%	11%	32%	11%	21%	11%	11%	0%	0%	0%
ENE (48)	50%	29%	23%	50%	23%	19%	8%	19%	2%	4%	4%
MET (45)	49%	47%	18%	18%	20%	16%	20%	11%	4%	2%	4%
CON (44)	59%	52%	18%	32%	27%	16%	7%	9%	5%	2%	2%
COM (27)	48%	19%	4%	48%	15%	11%	7%	11%	0%	4%	4%
TRA (65)	22%	6%	5%	75%	25%	6%	0%	6%	0%	0%	3%
ICT (53)	62%	15%	17%	26%	32%	23%	13%	15%	6%	0%	4%
FIN (24)	38%	21%	13%	21%	50%	54%	29%	8%	8%	0%	4%
HEA (27)	44%	11%	7%	30%	19%	26%	4%	11%	7%	22%	0%
MAN (43)	33%	9%	21%	44%	35%	21%	9%	21%	0%	0%	5%
TEC (102)	58%	29%	16%	37%	19%	17%	4%	14%	5%	0%	6%
MIS (28)	50%	14%	7%	11%	32%	18%	11%	14%	0%	7%	0%
Total (542)	**48%**	**24%**	**14%**	**39%**	**25%**	**18%**	**9%**	**13%**	**3%**	**3%**	**2%**

Table 7-3: Areas where OMT are applied against the sample total, by sector (n=542).

By company size

In the division by company size, no appreciable differences are found as far as how many employees a company might have. The greatest difference is in the use of Communications networks, with 10% more in large and medium-sized companies as compared with small firms. See Figura 7-10 and Table 7-4.

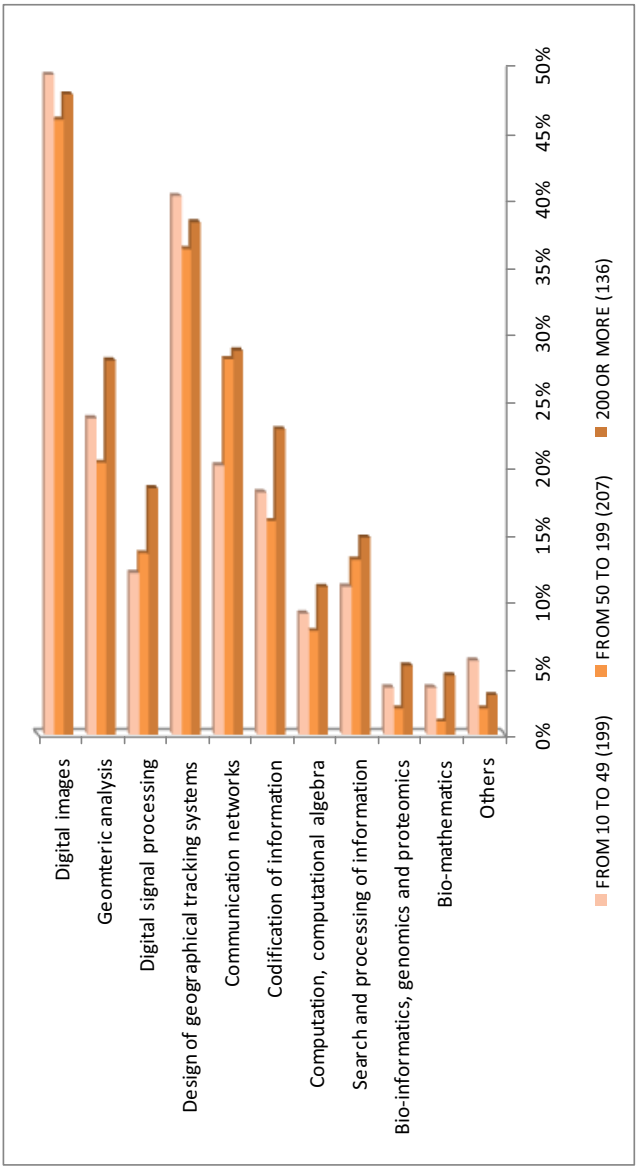


Figura 7-10: Areas where OMT are applied against the sample total and by company size (n=542).

Sector	Digital images	Geometric analysis	Digital signal processing	GIS or GPS	Commuications networks	Codification, cryptography	Computation, Computational algebra	Information search and processing	Bio-informatics, genomics and proteomics	Bio-mathematics	Others
FROM 10 TO 49	49%	24%	12%	40%	20%	18%	9%	11%	4%	4%	6%
FROM 50 TO 199	46%	20%	14%	36%	28%	16%	8%	13%	2%	1%	2%
200 OR MORE	48%	28%	18%	38%	29%	23%	11%	15%	5%	4%	3%
Total	**48%**	**24%**	**14%**	**39%**	**25%**	**18%**	**9%**	**13%**	**3%**	**3%**	**2%**

Table 7-4: Areas where OMT are applied against the sample total and by company size (n=542).

8 CAD/CAE, ST/OR AND OMT

8.1 Use of some of these techniques

In this section those companies that employ one or more of the techniques mentioned in previous sections – CAD/CAE, ST/OR and OMT – are analyzed. Of all the companies in the survey only 34% stated that they used none of these techniques. In Figure 8-1 one may observe that 66% of the companies in the sample use one or more of the mathematical techniques included in the questionnaire, which amounts to a total of 4,432 companies.

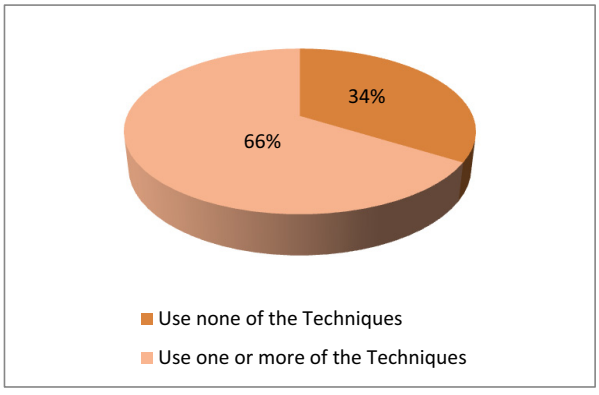


Figure 8-1: Companies using some of these mathematical techniques (n=6,716).

By sector

The sectors in which the highest level of application of the techniques analyzed in this document occur are *Metal and machinery* and *Technical services*, with approximately 79% of companies. This amounts to a more than 10% difference when seen against the sample total. *Energy, chemical and environment*, *Commerce*, *Timber and paper*, *ICT* and *Miscellaneous services* are also above this total with a range of between 72% and 67% of companies. See Figure 8-2.

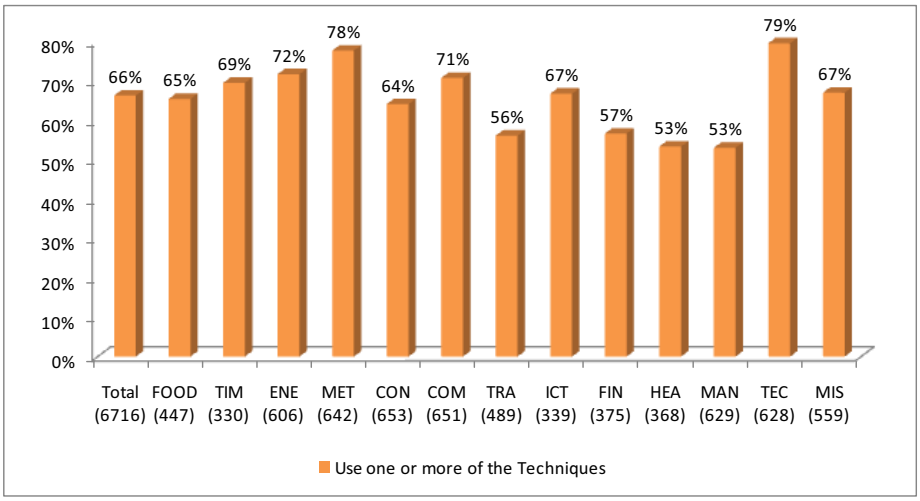


Figure 8-2: Companies using one or more of the mathematical techniques against the sample total, by sector.

When those companies that use none of the techniques covered on the study are analyzed, which amount to approximately half the companies in the survey, one finds that they belong to the *Finance* and *Health* sectors. See Figure 8-3.

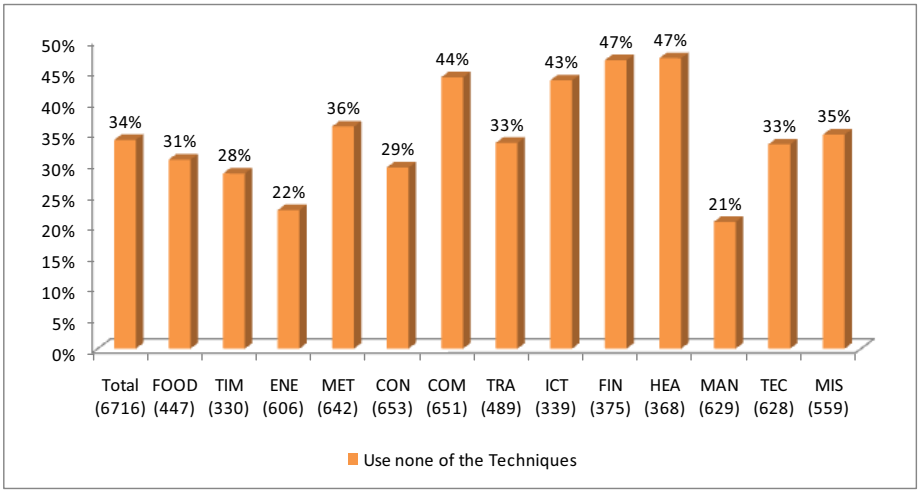


Figure 8-3: Companies in the sample total that use none of the techniques, by sector.

By company size

Segmentation by company size reveals a significant increase in the use of some mathematical techniques as company size increases, ranging from 59% in small companies to 80% in large companies (see Figure 8-4).

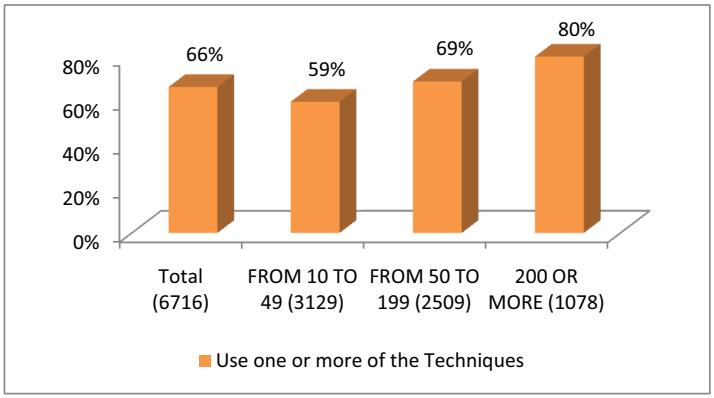


Figure 8-4: Companies using one or more of the techniques against the sample total, by company size.

Analysis of those companies using none of the techniques covered in this study shows an inverse behavior to that described above, with a range of between 41% in small companies and 20% of large companies stating that they use none of these techniques. See Figure 8-5.

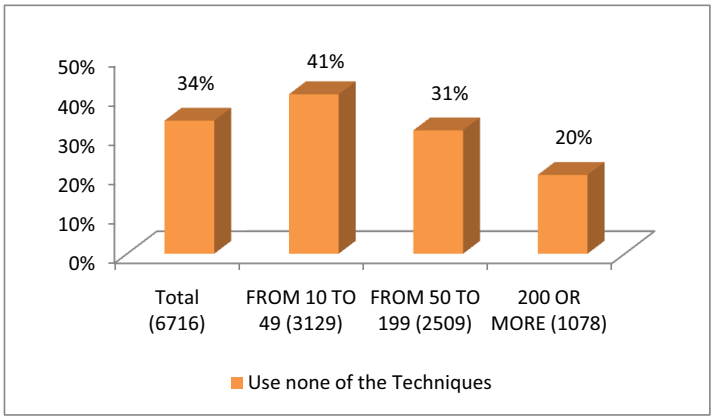


Figure 8-5: Companies using none of the mathematical techniques against the sample total, by company size.

8.2 Use of all the techniques

In this section we analyze those companies in the sample that employ all the mathematical techniques described in the questionnaire: CAD/CAE, Statistics and Operations research and OMT. Of all the companies interviewed only 1.41% make use of mathematical applications in all the areas covered in the survey, which amounts to a total of 95 companies. See Figure 8-6.

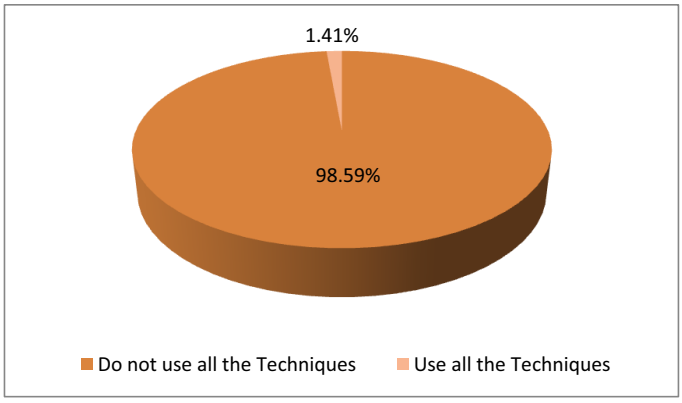


Figure 8-6: Companies using all the techniques analyzed in the questionnaire (n=6,716).

By sector

Figure 8-7 shows that from the companies using all the techniques analyzed in the study, the highest percentages are those belonging to the *Technical services* (3.34%), *Energy,*

chemical and environment (2.81%) and *Metal and machinery* (2.80%) sectors. This amounts to a total of 21, 17 and 18 companies, respectively.
Note that since in this section the percentages are much smaller, figures are given to two decimal points.

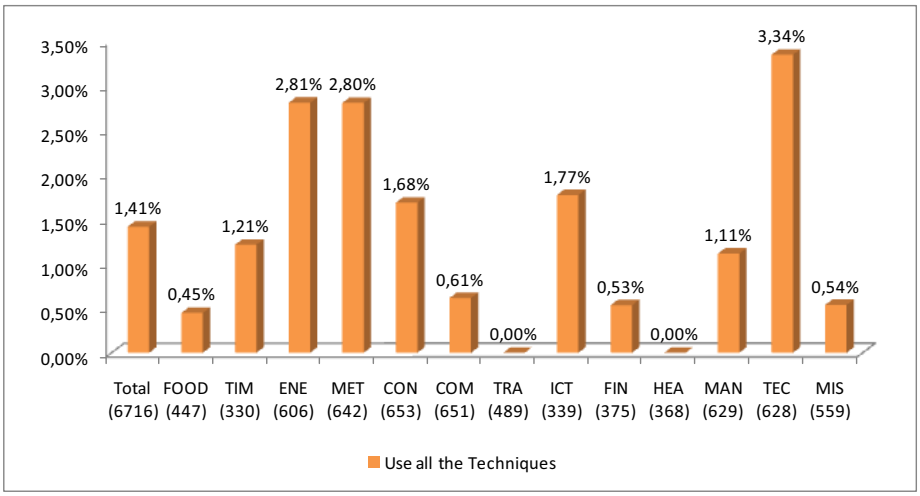


Figure 8-7: Companies using all the techniques against the sample total, by sector.

By company size

Division according to company size shows that the larger companies with 3.53% (38 companies) are those that make most use of all the techniques. See Figure 8-8.

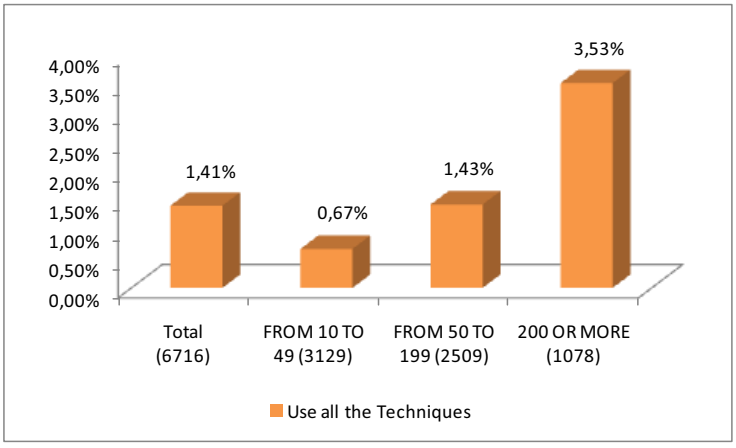


Figure 8-8: Companies using all the techniques against the sample total, by company size.

9 LEVEL OF KNOWLEDGE, HUMAN RESOURCES AND NEEDS

9.1 Level of knowledge of the mathematical techniques

Question C23 in the questionnaire asked the interviewees to score from 0 to 10 the level of knowledge of their companies as regards the possible application of the mathematical techniques covered in the questionnaire: CAD, CAE, ST/OR, etc. Figure 9-1 shows the percentages corresponding to these scores. 58% of those interviewed awarded points of between 5 and 10, while 29% stated a notable knowledge of these techniques with points equal to or higher than 7. It is also worth pointing out that 19% scored 0 points. Those companies that responded to the questionnaire with *Don't know/Didn't reply* were ruled out of the calculation of these percentages, yielding a base of 6,415 companies in all.

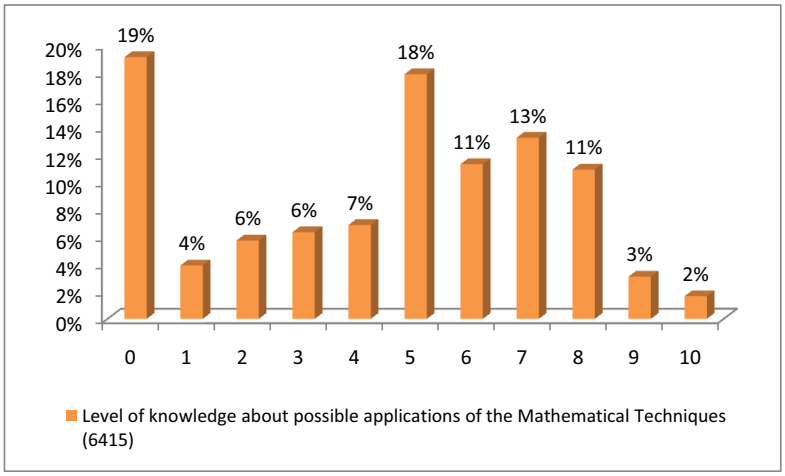


Figure 9-1: Level of knowledge of the mathematical techniques (n=6,415).

According to the mean score of the whole sample, although 58% would receive a pass mark, this would not reach a score of 5, since the mean is in fact 4.4 points; this is because of the high percentage of interlocutors who rated their companies' knowledge about the applicability of mathematical tools as 0. Table 9-1 and Figure 9-2 show the mean scores both by sector and by company size.

Sector	FROM 10 TO 49	FROM 50 TO 199	200 OR MORE	Total
FOOD	3.7	4.7	5.5	4.3
TIM	3.5	4.9	5.7	4.2
ENE	4.1	5.1	6.2	4.8
MET	4.6	5.9	6.9	5.4
CON	3.6	4.4	5.3	4.4
COM	3.5	4.5	5.5	4.5
TRA	3.2	3.9	5.0	3.7
ICT	5.3	4.8	5.0	5.1
FIN	3.9	3.1	6.3	3.8
HEA	3.5	3.3	4.8	3.6
MAN	3.7	3.8	4.1	3.8
TEC	5.3	5.7	6.0	5.5
MIS	3.6	4.0	4.5	4.0
Total	**4.1**	**4.5**	**5.4**	**4.4**

Table 9-1: Mean level of company knowledge of mathematical techniques by sector and by company size.

In Table 9-1 one may observe that among the small companies only those belonging to the *ICT* and *Technical services* sectors (5.3 points) attain a pass mark for company knowledge of these techniques. Three sectors attain a pass mark in the medium-sized company group: *Metal and machinery* (5.9 points), *Technical services* (5.7 points) and *Energy, chemical and environment* (5.1 points). It is in the large company group where the mean exceeds 5 points; in particular, in those companies with more than 199 employees and in the following sectors: *Metal and machinery* (6.9 points), *Finance* (6.3 points), *Energy, chemical and environment* (6.2 points) and *Technical services* (6 points), where the greatest perceived knowledge of the applications of the mathematical techniques addressed in this study are found. This behavior can be clearly appreciated in Figure 9-2, which shows the mean scores about the knowledge of these techniques in each sector and according to company size. The curve corresponding to large companies is always above that of the medium-sized companies, while this latter is always above that of the small companies; only in the *Information and Communication Technology* sector do the small companies score higher (5.3 points) than the medium-sized companies by half a point, and by 0.3 points higher than the large firms.

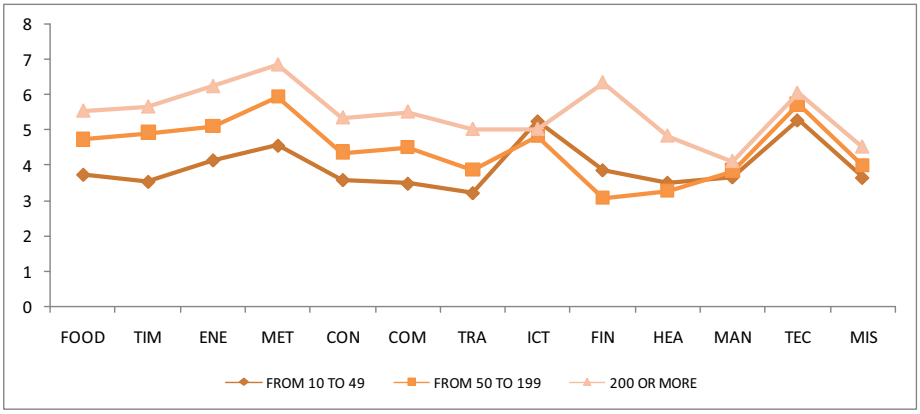


Figure 9-2: Mean level of knowledge about mathematical techniques by sector and company size.

9.2 Human resources with qualifications in Mathematics or Statistics

This section is devoted to the analysis of whether or not the companies have personnel qualified in mathematics or statistics on their workforce, and should they employ such personnel, how many there are and what activities they are engaged in within the company. Analysis is also conducted into whether the companies require some type of short- or medium-term mathematical service or personnel qualified in Mathematics or Statistics in order to apply any of the mathematical techniques addressed in this study. Figure 9-3 shows that 8% of companies stated that they have mathematicians or statisticians on their workforce. This represents a total of 565 companies from the 6,716 taking part in the survey. 6% answered *Don't know/Didn't reply*.

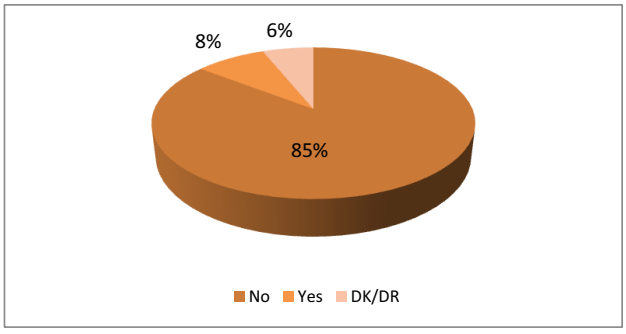
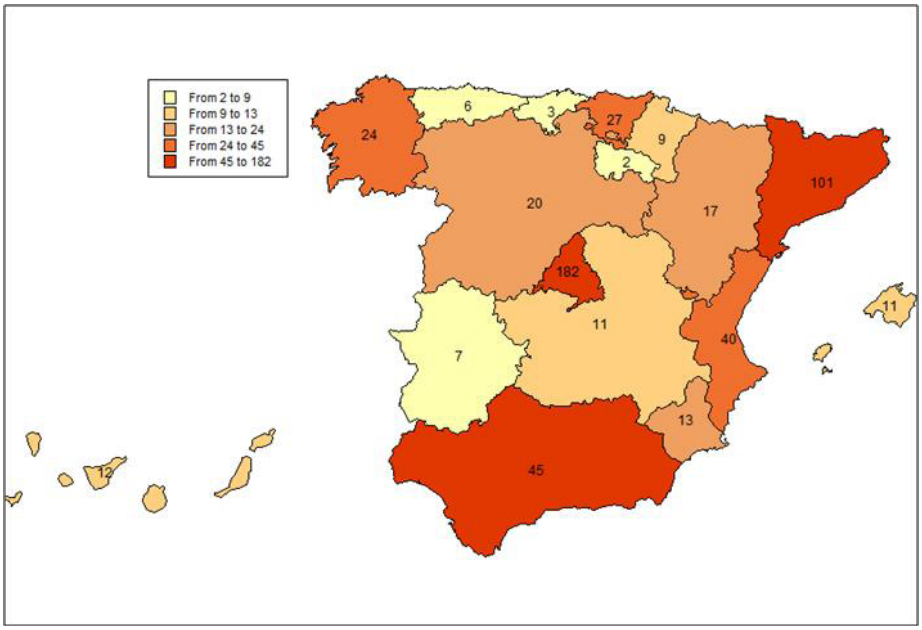


Figure 9-3: Companies with mathematicians or statisticians on their workforce (n=6,716).

These 565 companies were subsequently asked *How many mathematicians or statisticians they had on their workforce*. 35 (6%) did not reply to this question, so the number of mathematicians should be distributed among 530 companies. Adding all the replies referring to the number of mathematicians yields a total of 1,667 employees with this type of qualification.

By autonomous community

Map 9-1 shows the number of companies that employ mathematical personnel and that have also stated how many mathematicians or statisticians they have on their workforce according to Autonomous Community.



Map 9-1: Number of companies that employ mathematicians and how many such employees they have on their workforce, by autonomous community (n=530).

Table 9-2 shows the number of mathematicians or statisticians employed by the companies in the survey according to Autonomous Community; the number of companies that replied affirmatively to the question about whether they had mathematicians or statisticians on their workforce; the number of companies which, having replied affirmatively to the previous question, have also stated how many such personnel they employ, and also the number of companies selected in the sample in each autonomous community.

Community	Nº of companies not employing mathematicians	Nº of companies replying how many mathematicians	Nº of mathematicians	Total companies
ANDALUCIA	46	45	81	820
ARAGON	17	17	25	210
ASTURIAS	6	6	18	124
BALEARIC ISLANDS	11	11	29	137
CANARY ISALNDS	12	12	35	228
CANTABRIA	4	3	6	67
CASTILLA LA MANCHA	11	11	16	212
CASTILLA Y LEON	22	20	46	270
CATALUÑA	110	101	343	1,310
C. VALENCIANA	42	40	102	708
EXTREMADURA	7	7	16	82
GALICIA	25	24	95	359
MADRID	198	182	745	1,418
MURCIA	13	13	26	191
NAVARRA	9	9	16	119
BASQUE COUNTRY	30	27	62	418
LA RIOJA	2	2	6	43
Total	**565**	**530**	**1,667**	**6,716**

Table 9-2: Number of companies employing mathematicians and number of mathematicians per community.

By sector

Figure 9-4 provides details of the total number of mathematicians or statisticians by sector. Recall that the total amounts to 1,667 mathematicians spread over 530 companies.

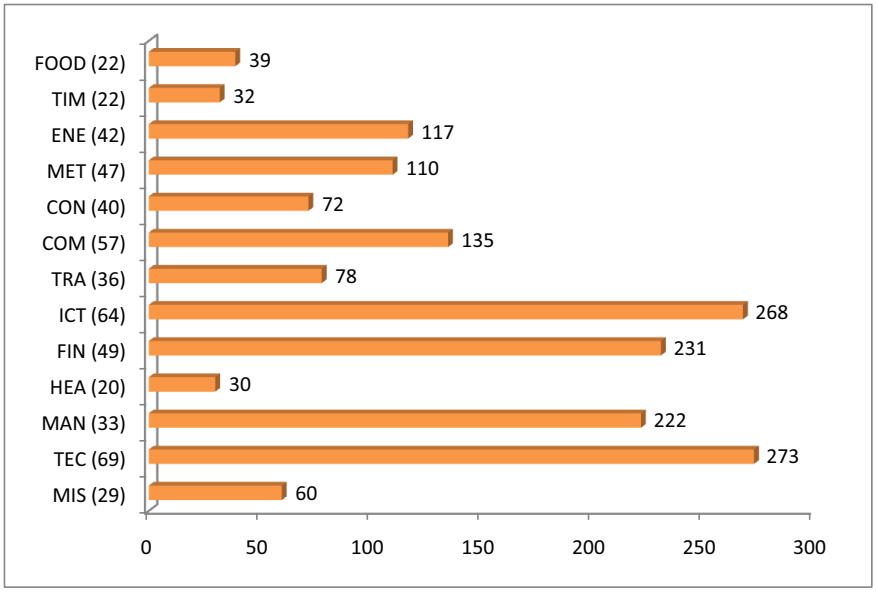


Figure 9-4: Number of mathematicians in the companies replying how many they employ, by sector (n=530).

By company size

As regards company size, a mean is given for the number of mathematicians employed by those companies that replied how many such employees with this profile they have on their workforce. As expected, the larger companies have a greater number of such employees, with a mean of between 5 and 6 mathematicians or statisticians in their workforce. Medium-sized companies have between 2 and 3, while the small companies employ between 1 and 2 people with this type of qualification.

9.2.1 Mathematicians´or statisticians´field of work

Question C27 in the questionnaire referred to the classification of the fields in which the mathematicians or statisticians were engaged in their work for their companies, the possible options were as follows:

1. *Business informatics or systems.*
2. *CAD/CAE*
3. *Statistics, data analysis and decision-making support.*
4. *Other mathematical techniques.*
5. *Other tasks.*

Figure 9-5 shows from the analysis of the replies that in 49% of companies mathematicians are engaged in fields associated with *Statistics, data analysis or decision-making support*, a percentage analogous to those engaged in *Business informatics or systems.* In 29% of companies mathematicians are engaged in *Other tasks*. It is important to point out that the question admitted multiple replies, so an employee engaged in *Other tasks* may also be working at the same time in another more mathematical field.

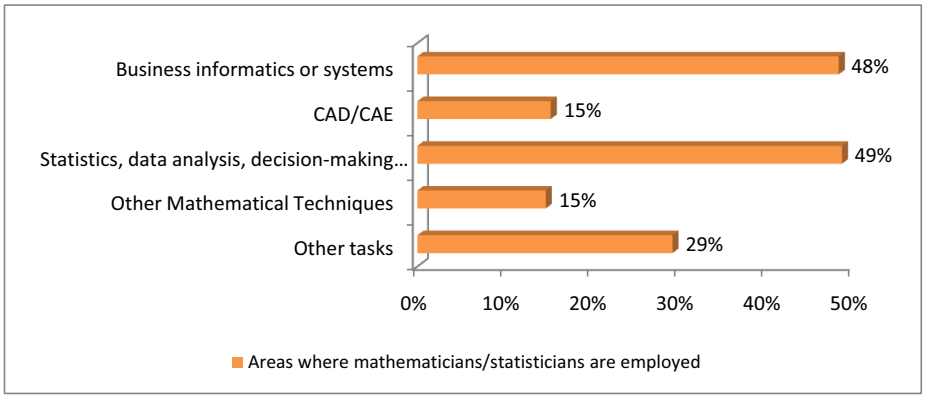


Figure 9-5: Percentage of companies according to the fields in which their mathematicians are working (n=530).

By company size

In the segmentation by company size one may see that in 60% of those large companies that employ personnel with qualifications in mathematics, these mathematicians are engaged in *Business informatics or systems*, a figure that coincides with the percentage of large companies in which mathematicians are engaged in *Statistics, data analysis and decision-making support*. Large companies with personnel specializing in CAD/CAE yield a considerably lower figure of 21%. All these percentages are higher than those obtained for small and medium-sized companies employing personnel with this profile in the same fields (Figure 9-6). On the other hand, the highest percentage of companies with mathematicians devoted to *Other tasks* incommensurate with their qualifications is found in the small companies, with 36%, as a against the large companies, with 24%. Therefore, with the exception of OMT, those companies with the largest workforce are those which engage their mathematicians in fields most in agreement with their qualifications.

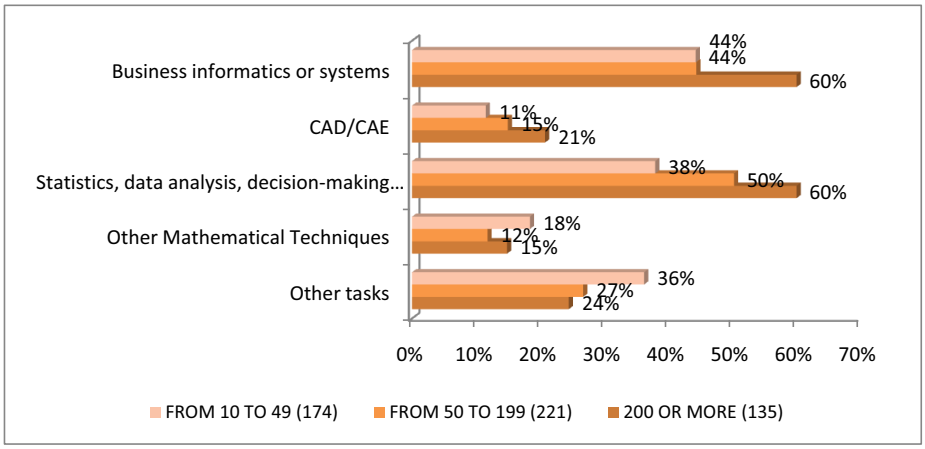


Figure 9-6: Percentage of companies according to the fields in which their mathematicians work, by company size (n=530).

Out of the sample of 1,667 mathematicians, Figure 9-7 shows those mathematicians or statisticians employed by the companies, as well as a breakdown by sector of how many of them are devoted, at least partially, to any of the tasks involving the main techniques addressed in this study: CAD/CAE, ST/OR and OMT. Thus, for example, 98% are engaged in fields directly related to their qualifications in the *Metal and machinery* and *Energy, chemical and environment* sectors, while this figure falls to 77% in the *Health* sector. Note that the percentage of companies employing their mathematicians for work in Other Tasks is higher in small companies, which are those having the fewest mathematicians in their workforce.

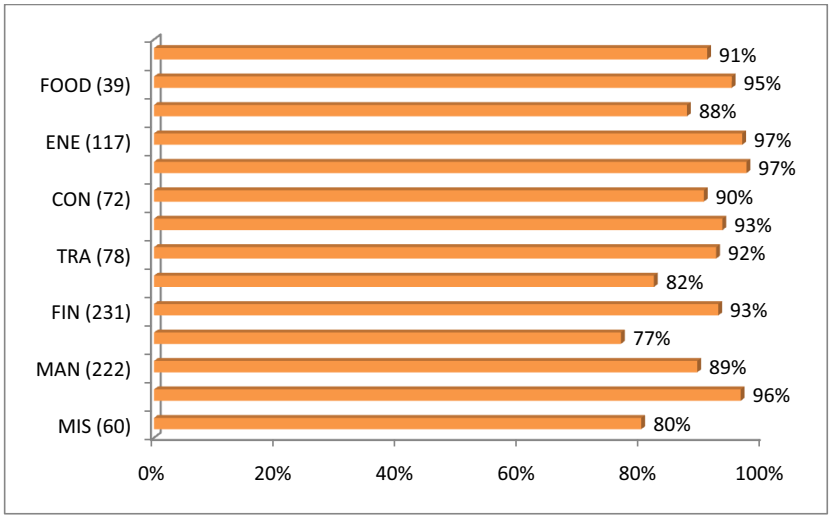


Figure 9-7: Percentage of mathematicians or statisticians in companies using CAD/CAE, ST/OR or OMT, by sector (n=1,667).

9.3 Need for mathematical services or qualified mathematicians

We now analyze short- or medium-term company requirements for some type of mathematical service or the need to appoint qualified mathematicians or statisticians. 5% of interviewees stated that their company required mathematical services or needed to appoint personnel qualified in Mathematics or Statistics in order to apply one or more of the techniques considered in the survey. This amounts to a total of 358 companies. See Figure 9-8.

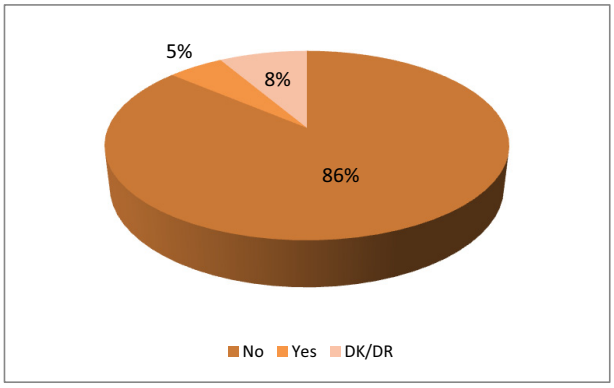


Figure 9-8: Need for mathematical services or qualified mathematicians (n=6,716).

By sector

Analysis by sector (see Figure 9-9) shows that the *ICT* (12%) and *Finance* (9%) sectors are those most interested in appointing mathematical personnel or state their need for some type of service in this sphere.

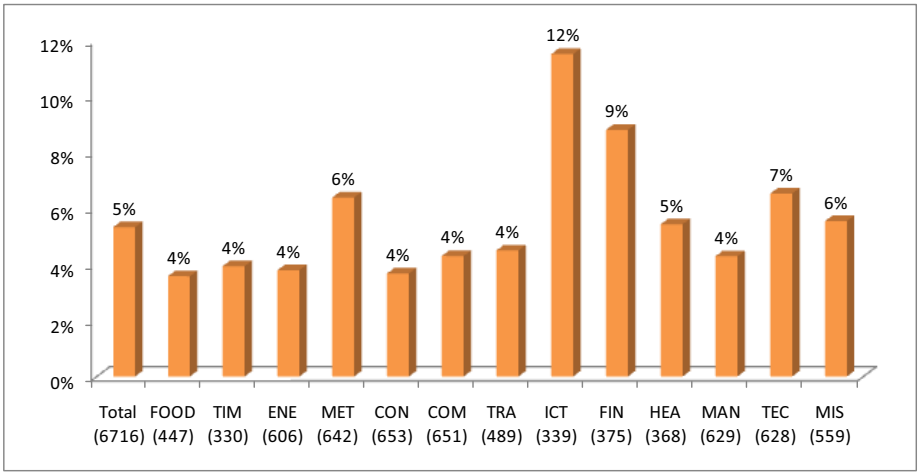


Figure 9-9: Need for mathematical services or qualified mathematicians, by sector.

Analysis of distribution by sector (see Figure 9-10) shows that 358 companies state their need in the future for mathematical services or personnel qualified in mathematics, with more than 8% in the *Metal and machinery*, *ICT*, *Technical services*, *Finance* and *Miscellaneous service* sectors, the first three of these sectors reaching a figure of 11%.

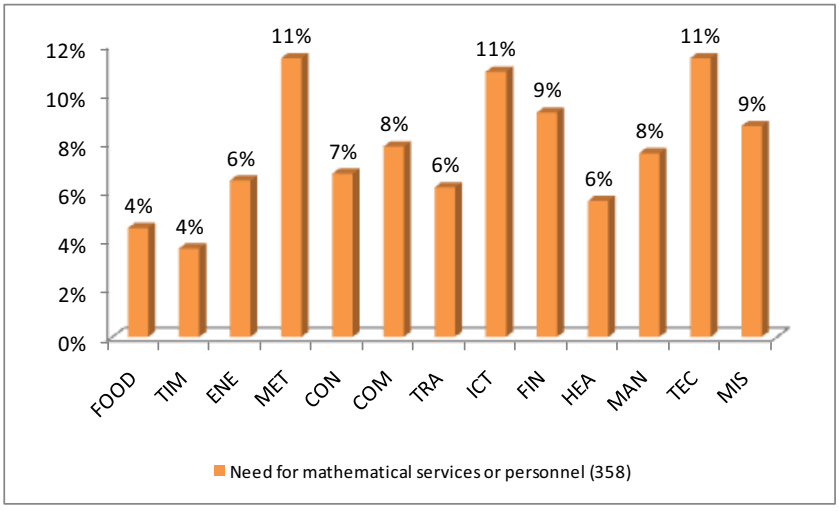


Figure 9-10: Distribution of companies with the need for mathematical services or qualified mathematicians, by sector.

By company size

When each group according to company size is compared against the percentage for the sample total, one observes that the largest companies give a figure of 8%, which is 3% above the mean value and double the figure (4%) for small companies. See Figure 9-11.

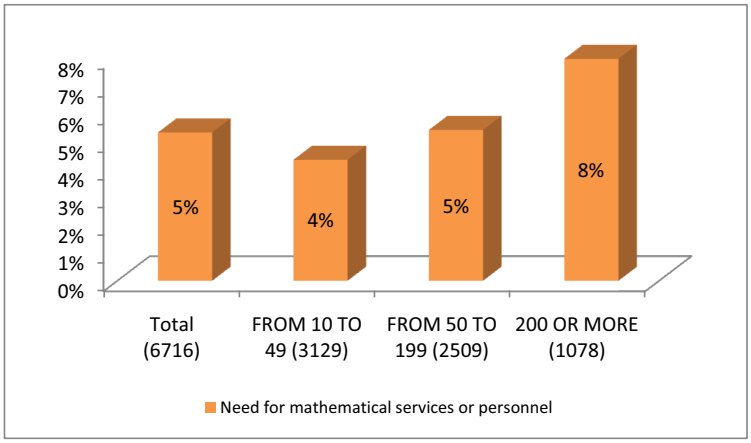


Figure 9-11: Need for mathematical services or qualified mathematicians, by company size.

Taking once again as a base those companies stating their need for mathematical services or interest in appointing mathematical personnel, and analyzing the distribution by company size, one sees that 76% correspond to small or medium-sized companies; this is due to the fact that these two groups are far more numerous than the large company group (see Figure 9-12).

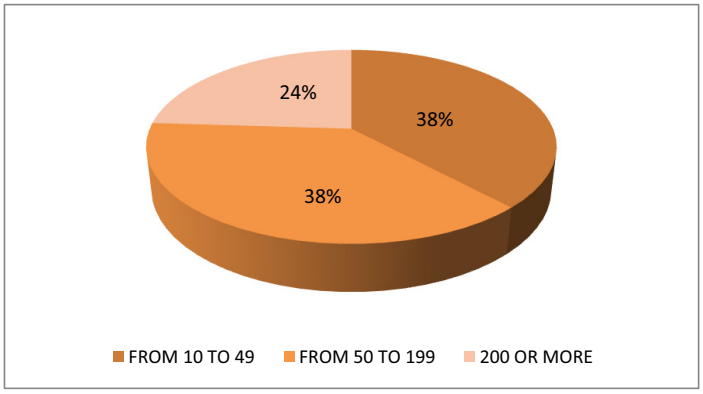


Figure 9-12: Distribution of companies with the need for mathematical services or qualified mathematicians, by company size (n=358).

9.3.1 From among the companies using CAD/CAE, ST/OR or OMT

The studied detailed above in Section 9.3 is now repeated, but this time by taking only those companies in the sample that stated their use of CAD/CAE, ST/OR or OMT.

Of the total number of companies in the sample, 66% make use of one or more of the techniques concerned, which amounts to 4,445 companies.

Figure 9-13 shows the sample divided into two groups; the first is composed of those 4,445 companies that use some type of mathematical or statistical techniques, while the second consists of the remaining 2,271 companies in the sample that stated that they do not use any of the techniques referred to in the questionnaire.
7% of the companies in the first group indicated that they have short- or medium-term requirements for mathematical services or personnel qualified in Mathematics or Statistics, while in the second group this figure falls to only 2%.

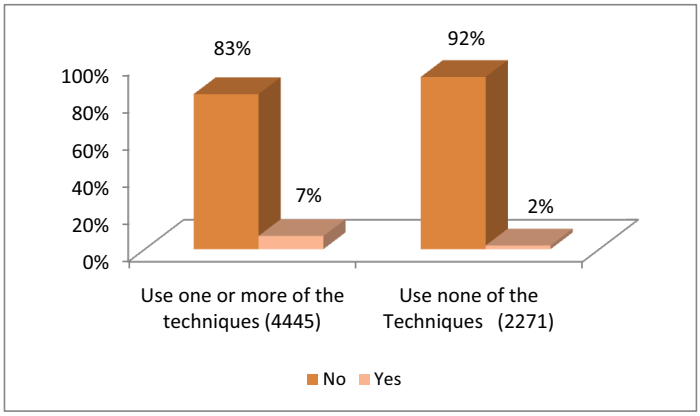


Figure 9-13: Need for mathematical services or qualified mathematicians, according to whether or not the company uses mathematical techniques.

10 COLLABORATION AND OUTSOURCING WITH UNIVERSITIES OR RESEARCH CENTERS (RC)

This section is first devoted to assessing the interest shown by companies in possible collaborations with Universities or RC in the sphere of the techniques addressed in this study. A study is then made of the collaboration and outsourcing conducted with Universities or RC over the last five years for any sphere, not only in mathematics; these collaborations include training and research projects and technological services.

10.1 Interest in collaborating with Universities or RC

As regards this point, question C24 in the questionnaire asks whether the company would be interested in collaborating with universities or RC in end-of-course projects, master course projects or work experience placements in the sphere of mathematics. 32% of all replies were affirmative and 24% corresponded to *Don't know/Didn't reply* (see Figure 10-1). The high percentage of *Don't know/Didn't reply* responses is hardly surprising, since as reported in Section 4.2 only 20% of interviewees hold management posts, while approximately only 7% occupy posts responsible for research, innovation, methods, quality, etc., interlocutors belonging to these two latter categories being the most ideally suited to answering question C24.

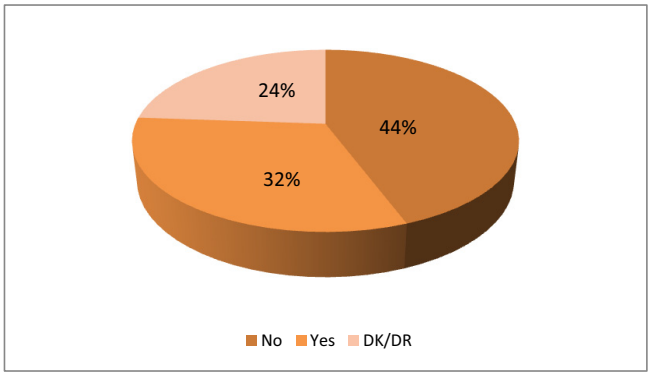


Figure 10-1: Companies ready to collaborate with Universities or RC (n=6,716).

By sector

The sectors most willing to enter into collaboration are *ICT* and *Technical services*, which account for almost half of these companies, followed by the *Metal and machinery* sector with 38% (see Figure 10-2).

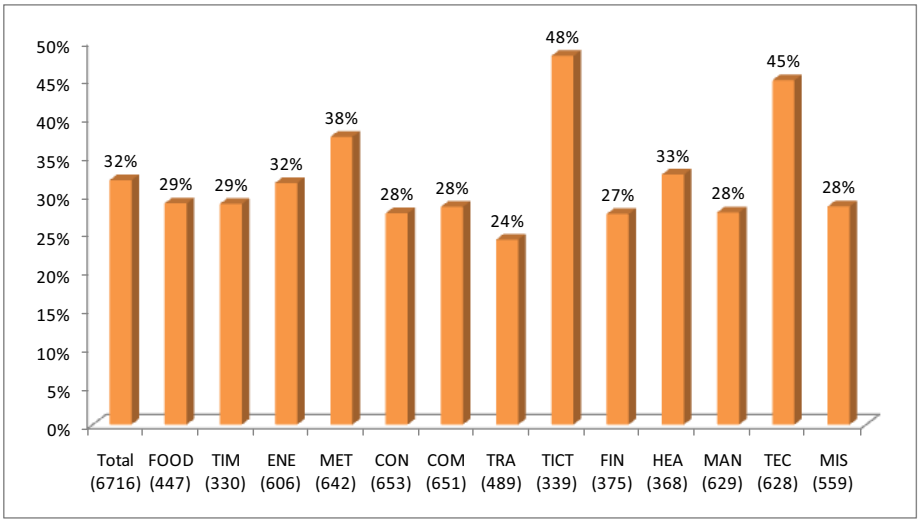


Figure 10-2: Companies ready to collaborate with Universities of RC, by sector.

If the base is confined to the 2,140 companies stating that they were willing to collaborate with Universities and RC, and if their distribution is analyzed by sector, one observes that 13% belong to the *Technical services* sector and 11% to the *Metal and machinery* sector, which coincides with that stated above (see Figure 10-3). The fact that only 8% corresponds to the *ICT* sector is not surprising if we take into account that this is a low population sector with only 339 companies when compared with the afore-mentioned sectors of 628 and 642. This means that in relation to the sample total the representation of this sector is lower.

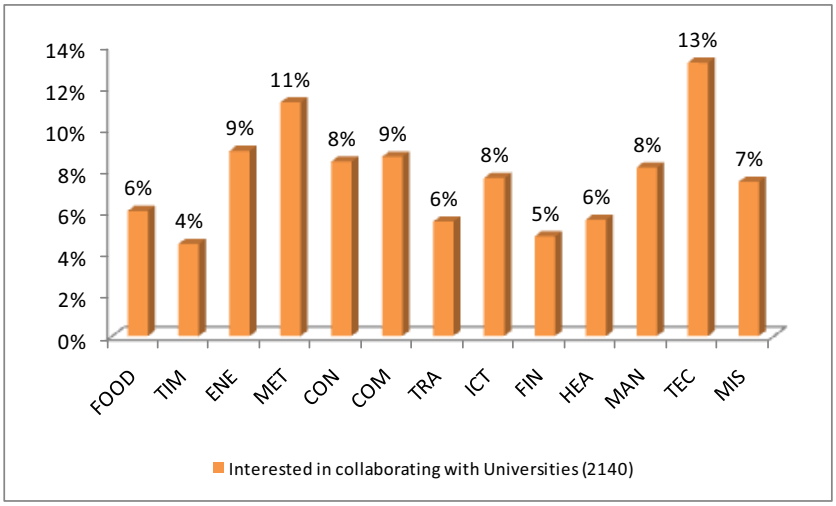


Figure 10-3: Distribution of companies prepared to collaborate with Universities or RC (n=2,140).

By company size

In the segmentation by company size (Figure 10-4) it is the larger companies that express the most interest in collaborating with Universities or RC, with a figure of 43% of all those in the sample.

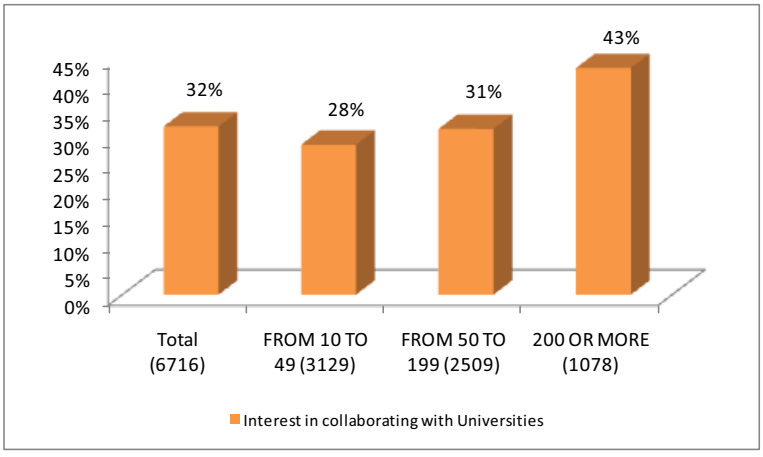


Figure 10-4: Companies ready to collaborate with universities or RC, by company size.

Figure 10-5 shows the percentages distributed according to company size against the total number of companies willing to collaborate with Universities or RC.

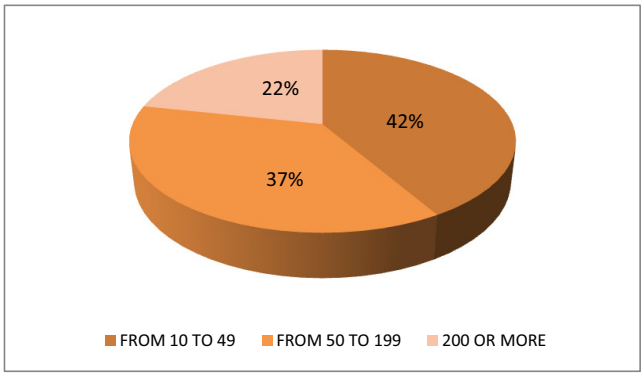


Figure 10-5: Distribution of companies willing to collaborate with Universities or RC, by company size.

10.1.1 Users of some mathematical techniques but with no interest in collaborating with Universities or RC

A relative analysis is now made of the companies stating that they use one or more of the mathematical techniques referred to in the questionnaire (CAD/CAE, ST/OR or OMT), but focusing on those companies that would not be interested in collaborating with Universities or RC.

Recall that the number of companies using one of more of the techniques addressed in this study is 4,445 (66%). In the following sections, the percentage of these companies that express no interest in collaboration is calculated (see Figure 10-6 and Figure 10-7). These percentages are also calculated against the total number of companies in the sample. Thus it transpires that 34% of the 4,445 companies that use some such technique would not be prepared to collaborate with Universities or RC. This 34% is equivalent to 23% of companies with respect to the total.

By sector

Figure 10-6 shows the percentages calculated against the total number of companies surveyed in each sector. Thus, for example, of the companies belonging to the *Food and clothing* sector, 65% make use of CAD/CAE, ST/OR or OMT, and 40% of these companies would not be interested in collaborating with Universities or RC; this 40% is equivalent to 26% when calculated against the total number of companies in this sector (see Figure 10-7).

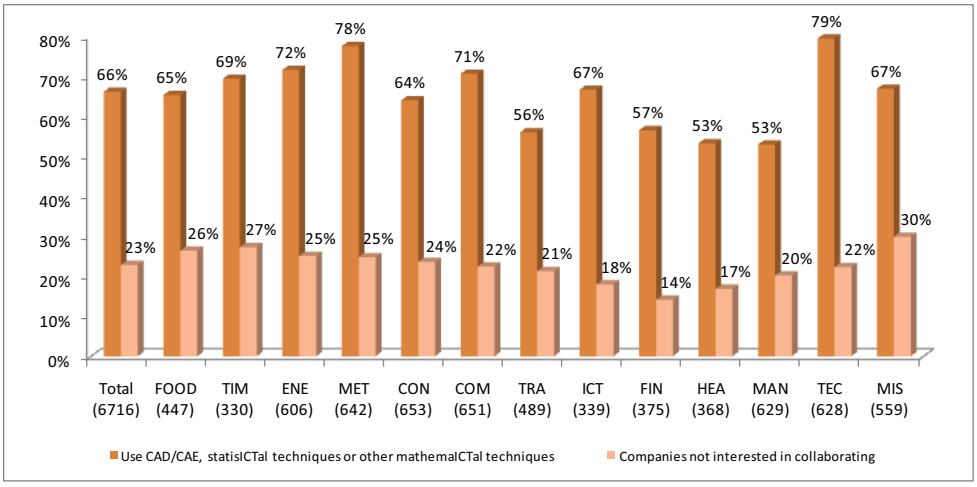


Figure 10-6: Companies not interested in collaboration with Universities or RC, by sector.

Figure 10-7 shows the percentages of those companies that while being users of CAD/CAE, ST/OR or OMT are not interested in collaborating with Universities or RC. Practically half of the companies in the *Construction*, *Transport and storage*, *Management services* and *Miscellaneous services* sectors that use some mathematical technique express no interest in collaborating with Universities or RC.

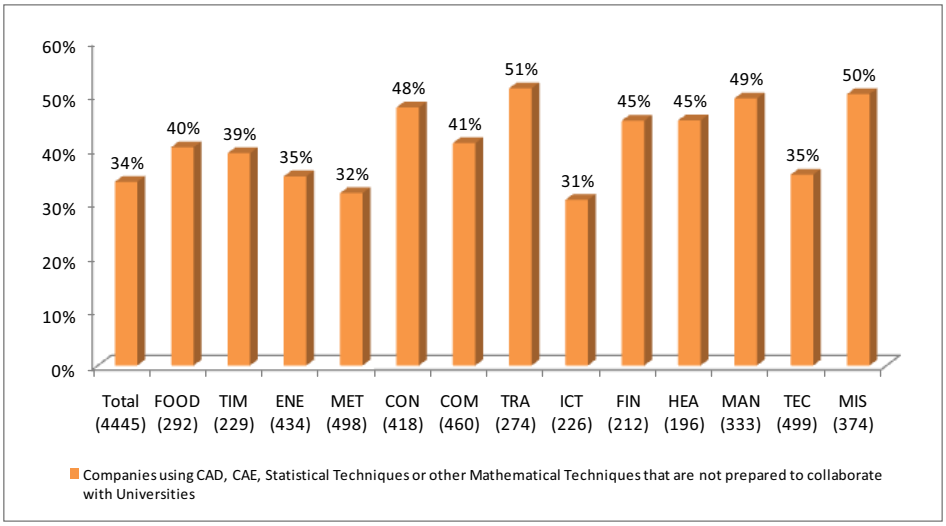


Figure 10-7: Companies using some mathematical technique but not interested in collaborating with Universities or RC, by sector.

By company size

Figure 10-8 shows the sample divided into three groups. One observes that the larger companies express the greatest interest in collaboration, since only 17% state that they would not be interested. This amounts to 182 companies in the sample, which correspond to the 21% in Figure 10-9.

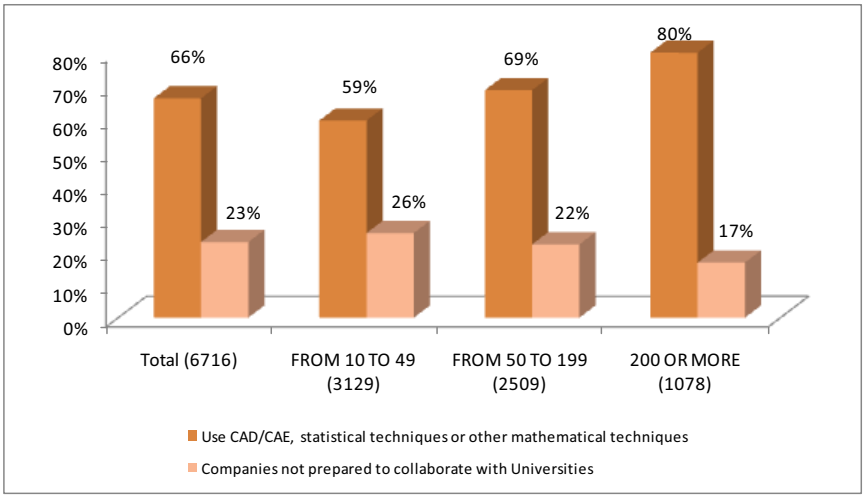


Figure 10-8: Companies not ready to collaborate with Universities or RC, by company size.

In Figure 10-9 one again observes the trend that the larger the company the greater the interest in collaborating with Universities or RC.

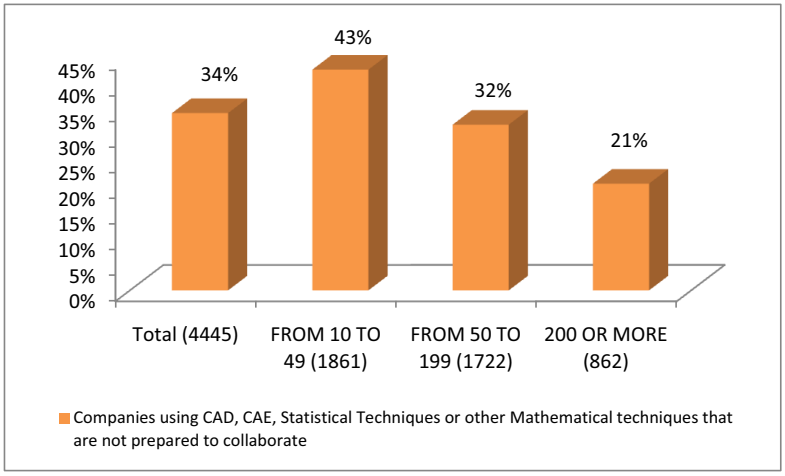


Figure 10-9: Companies using some mathematical techniques but not interested in collaborating with Universities or RC, by company size.

10.1.2 OMT users prepared to collaborate with Universities or RC

We now analyze by sector those companies which, while being users of OMT, would indeed be prepared to collaborate with Universities or RC.

Taking as a base the 542 companies that make use of OMT, one finds that half of such firms would be interested in collaborating with Universities or RC. This amounts to 4% of the 6,716 companies that comprise the sample.

By sector

In the analysis by sector, *ICT* and *Finance* yield a figure of more than 66%. See Figure 10-10.

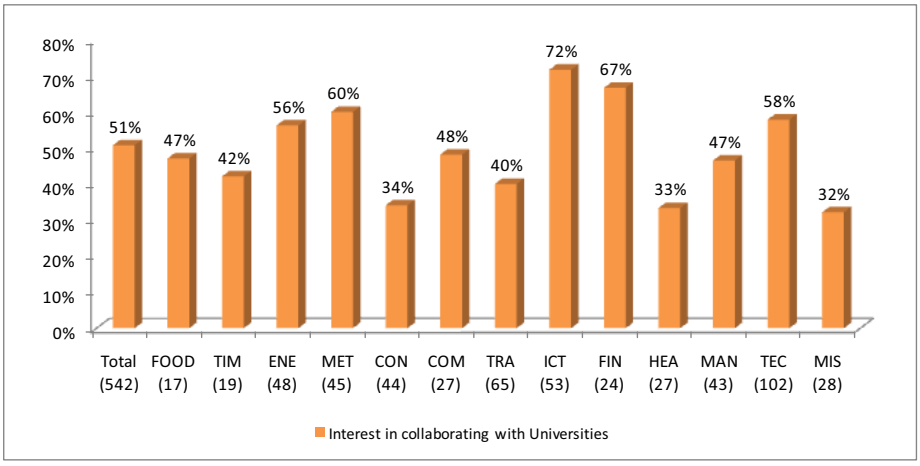


Figure 10-10: OMT user companies ready to collaborate with Universities or RC, by sector (n=542).

By company size

On dividing by group according to company size, 46% of small companies and 60% of larger companies would be interested in collaboration. See Figure 10-11.

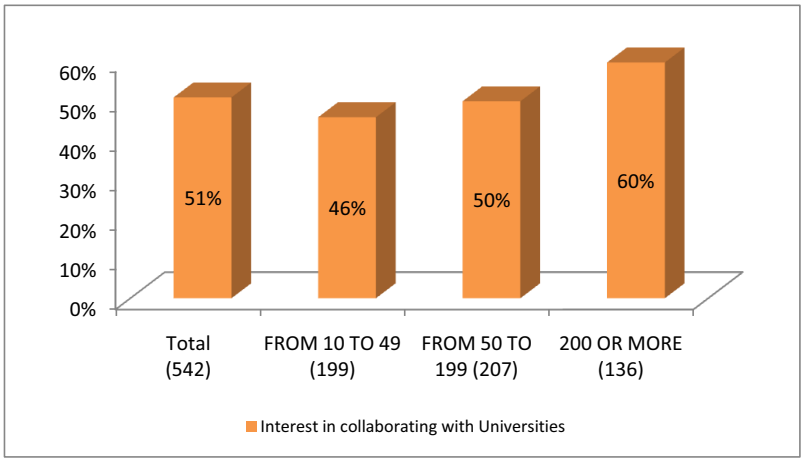


Figure 10-11: OMT user companies interested in collaborating with Universities or RC, by company size (n=542).

10.1.3 Requiring some mathematical technique and prepared to collaborate with Universities or RC

This section is devoted to an analysis of which among those companies stating some requirement in CAD/CAE or ST/OR would be prepared to collaborate with Universities or RC. To that end, the 620 companies expressing the need for some assistance with CAD/CAE or ST/OR are taken as the base.

By sector

75% of the companies belonging to the *Metal and machinery* sector that state some type of requirement for the techniques considered would be interested in collaborating with Universities or RC, while in the *Technical services* sector this figure is 72%. The lowest percentage of 39% is found in the *Transport and storage* sector. See Figure 10-12.

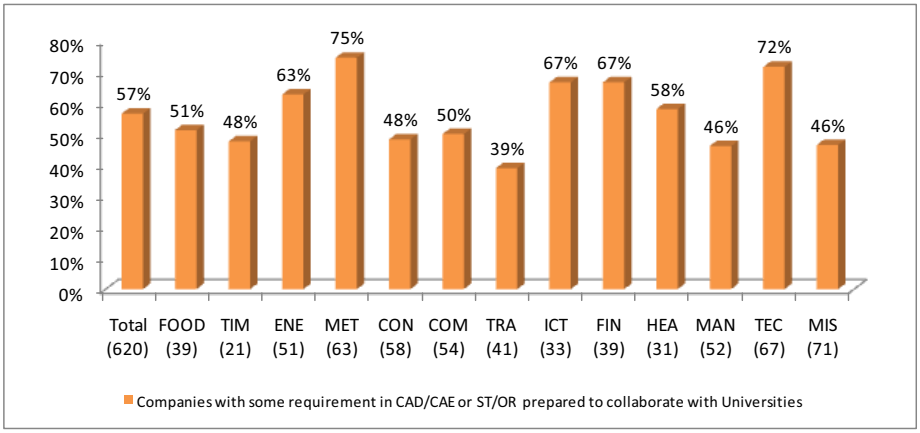


Figure 10-12: Companies with some requirement in CAD/CAE or ST/OR ready to collaborate with Universities or RC, by sector.

By company size

Of those companies that state the need for some type of assistance in CAD/CAE and/or ST/OR, the larger companies are those that are most willing to collaborate with Universities or RC, with a figure of 73%. Approximately half the small and medium-sized companies state their interest in collaboration. See Figure 10-13.

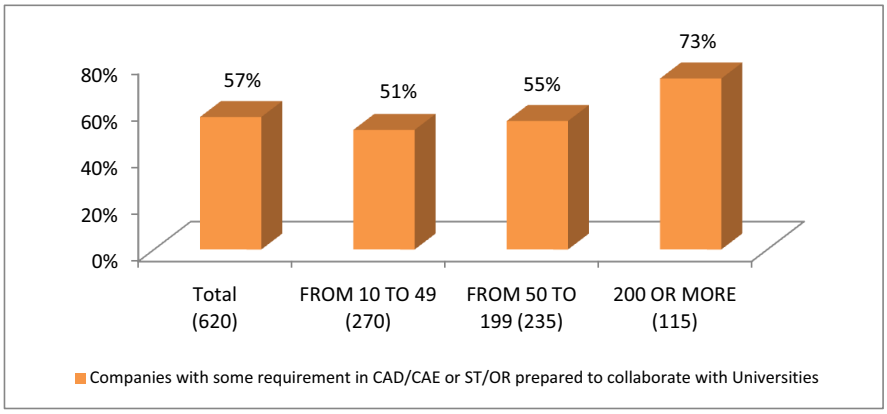


Figure 10-13: Companies with some requirement in CAD/CAE or ST/OR ready to collaborate with Universities or RC, by company size.

10.2 Outsourcing and collaboration with Universities or RC in the last five years

What follows is an analysis of those companies that over the last five years have collaborated with Universities and RC in *training, research* or *technological service* projects, but not necessarily in fields related to mathematics. 31% of the 6,716 companies sampled responded affirmatively to the question, which gives a total of 2,100 companies. See Figure 10-14.

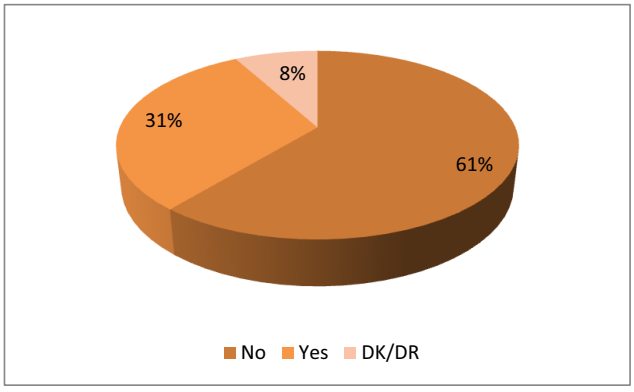
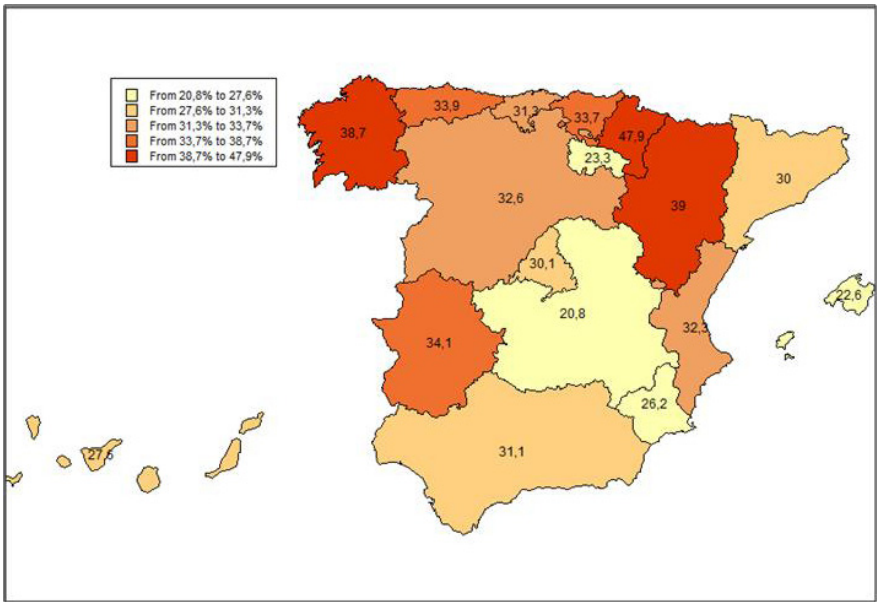


Figure 10-14: Companies that have collaborated with Universities or RC in the last five years (n=6,716).

By Autonomous Community

In the analysis according to Autonomous Community, Navarra comes out top with almost half of its companies, followed by the Communities of Aragón and Galicia, each with approximately half its companies. Companies in the Communities of Castilla La Mancha, the Balearic islands and La Rioja, however, are those which have collaborated or outsourced least with Universities and RC over the last five years, all with a figure of around 20%. See Map 10-1.



Map 10-1: Companies that have collaborated with Universities or RC in the last five years (n=6,716).

Table 10-1 gives the sample sizes for each community as well as the percentages shown in Map 10-1.

Community	Have collaborated
ANDALUCÍA (820)	31.1%
ARAGÓN (210)	39.0%
ASTURIAS (124)	33.9%
BALEARIC ISLANDS (137)	22.6%
CANARY ISLANDS (228)	27.6%
CANTABRIA (67)	31.3%
CASTILLA-LA MANCHA (212)	20.8%
CASTILLA-LEÓN (270)	32.6%
CATALUÑA (1,310)	30.0%
COMUNIDAD VALENCIANA (708)	32.3%
EXTREMADURA (82)	34.1%
GALICIA (359)	38.7%
MADRID (1,418)	30.1%
MURCIA (191)	26.2%
NAVARRA (119)	47.9%
BASQUE COUNTRY (418)	33.7%
LA RIOJA (43)	23.3%
Total (6,716)	**31.3%**

Table 10-1: Companies that have collaborated with Universities or RC in the last five years (n=6,716).

By sector

The companies in sectors that have had the most collaborations or outside contracts with Universities or RC over the last five years are those involved in *ICT* and *Technical services*, with 53% and 47%, respectively, while the sector with the fewest such collaborations is *Transport and storage* with 19% of its companies, these latter firms thus coinciding with figures previously observed in the sector, which is the one in which the least interest in collaborations was expressed. See Figure 10-15.

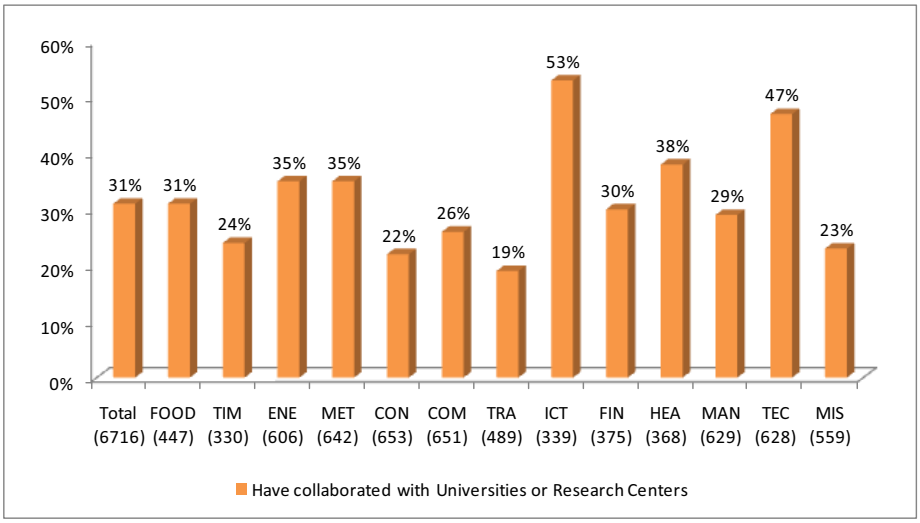


Figure 10-15: Companies that have collaborated with Universities and RC in the last five years, by sector.

By company size

As in the previous sub-section, the large companies are those that have been most involved in collaborations with Universities and RC during the last five years, with a figure of 45%. See Figure 10-16.

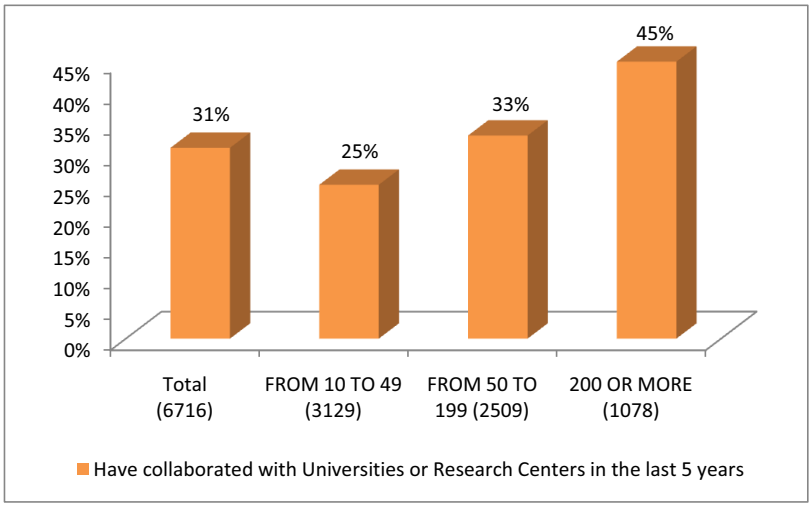


Figure 10-16: Companies that have collaborated with Universities and RC in the last five years, by company size.

10.2.1 Interest in maintaining collaboration

In this section we analyze those companies belonging to the group replying that they have had collaborations or outside contracts with Universities or RC in the last five years, which have expressed an interest in renewing their collaboration.

If we take as a base those companies that have previously had some type of collaboration with Universities or RC (2,100) and now observe their interest in doing so again, we find that 59% would be prepared to resume collaboration while 23% would not. This 59% of companies interested in collaborating again amounts to 1,239 firms, which in turn are equivalent to 19% of the total number of companies. See Figure 10-17.

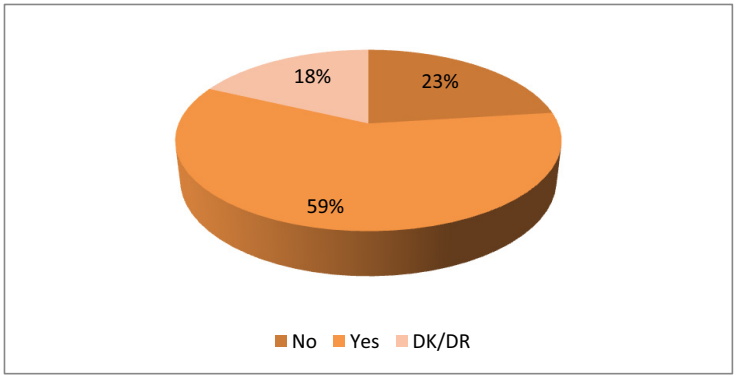


Figure 10-17: Interest in collaborating again or not with Universities or RC (n=2,100).

By sector

Table 10-2 shows those companies which, having previously collaborated with Universities or RC, do not intend to continue collaborating. The second column shows the percentages in terms of the 2,100 companies that have already collaborated, while the third column shows them against the total number of companies in the survey. The Table presents a breakdown by sector; thus, 7% of companies out of the total number do not intend to resume collaboration, which amounts to 23% of the 31% of companies that have collaborated with Universities or RC. See Figure 10-18.

Sector	Do not intend to collaborate again (n=2,100)	Do not intend to collaborate again (n=6,716)
FOOD (447)	22%	7%
TIM (330)	22%	5%
ENE (606)	24%	8%
MET (642)	14%	5%
CON (653)	19%	4%
COM (651)	25%	6%
TRA (489)	26%	5%
ICT (339)	27%	14%
FIN (375)	23%	7%
HEA (368)	30%	12%
MAN (629)	24%	7%
TEC (628)	21%	10%
MIS (559)	24%	6%
Total (6,716)	**23%**	**7%**

Table 10-2: Companies not interested in collaborating again with Universities or RC, by sector.

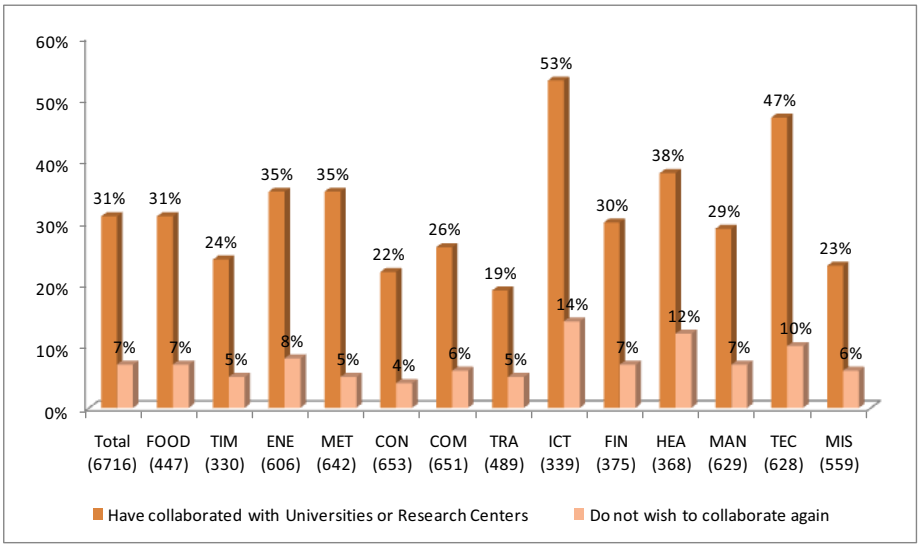


Figure 10-18: Companies not interested in collaborating again with Universities or RC, by sector.

10.2.2 Type of collaboration

Question C29 in the questionnaire asked all those companies that had had collaborations or contracts with Universities or RC in the last five years, in what fields such collaborations had been conducted. The three possible replies to this question were as follows:

1. *Training.*
2. *Research or technological services.*
3. *Both.*

Taking as a base the 2,100 companies that have had some type of collaboration, 78% of such cases were in the field of *Training* and 36% in *Research or technological services*. 17% of such companies collaborated with Universities or RC in *Both fields*, while 3% responded *Don't know/Didn't reply*.

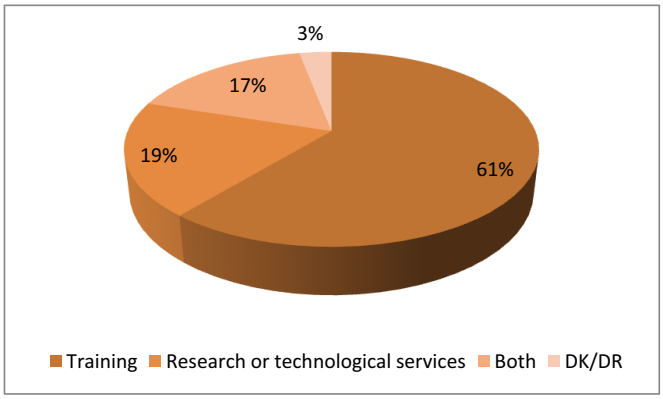


Figure 10-19: Type of collaboration with Universities or RC (n=2,100).

By sector

Table 10-3 shows the percentages for the type of collaboration against the total number of companies that have collaborated with Universities or RC in each sector. Thus, 89% of companies in the *Miscellaneous services* sector have collaborated in *Training*, which is the highest figure, while 57% in the *Energy, chemical and environment* sectors have collaborated in *Research or technological services*. Among the sectors that have collaborated in *Both fields*, it is worth pointing out *Energy, chemical and environment*, with 23%, *Metal and machinery*, with 22%, and *Food and clothing*, with 21%. See Figure 10-20.

Sector	Training	Research or technological services	Both
FOOD (138)	54%	23%	21%
MAD (79)	51%	24%	16%
ENE (213)	39%	34%	23%
MET (224)	46%	30%	22%
CON (146)	69%	16%	12%
COM (170)	66%	18%	13%
TRA (91)	67%	14%	16%
ICT (181)	64%	17%	15%
FIN (111)	69%	12%	14%
HEA (141)	70%	11%	16%
MAN (183)	74%	9%	11%
TEC (293)	60%	19%	20%
MIS (130)	81%	9%	8%
Total (2,100)	**61%**	**19%**	**17%**

Table 10-3: Type of collaboration with Universities or RC, by sector.

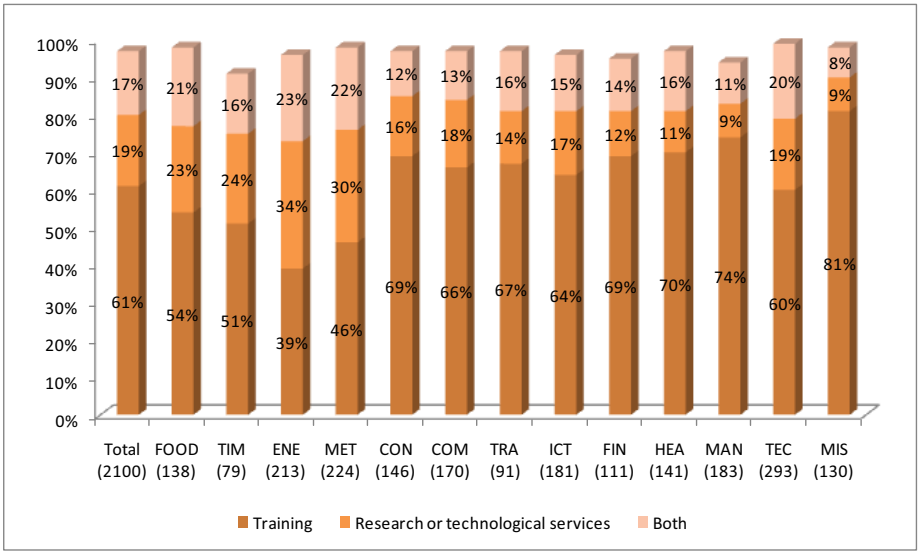


Figure 10-20: Type of collaboration with Universities or RC, by sector.

By company size

In this case it is the small and medium-sized companies that have most collaborated in *Training*, with figures of 80% and 78%, respectively. As regards *Research or technological services*, it is the large companies that have had most collaboration or contracts of this type, with 43%. The large companies have also outsourced most in *Both* fields. See Figure 10-21.

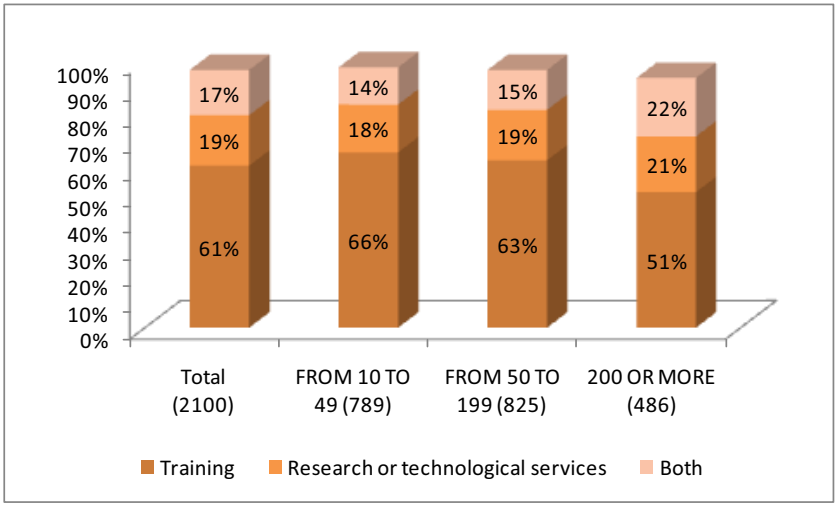


Figure 10-21: Type of collaboration with Universities or RC, by company size.

Degree of satisfaction

Figure 10-22 reflects the degree of satisfaction expressed by companies collaborating with Universities or RC according to points awarded from 0 to 10. Of the 2,100 companies that have collaborated in this way, 8% failed to reply to the level of satisfaction, leading to a base of 1,939 companies. As one may observe in the graph, 2% of these companies expressed a degree of satisfaction of less than 5, while 79% expressed a high degree of satisfaction with points equal to or higher than 7.

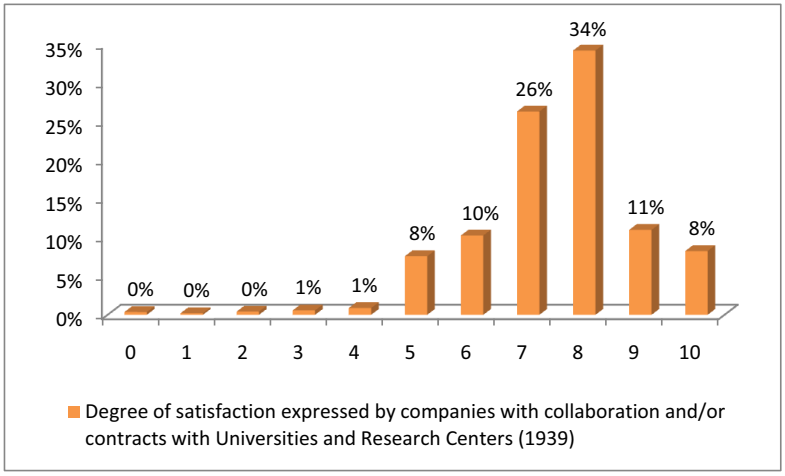


Figure 10-22: Degree of satisfaction expressed by companies collaborating with Universities or RC.

By sector

Calculation of the average number of points awarded reveals that satisfaction with collaboration is high, with 7.45 out of 10. In the division by sector, the highest points correspond to *Health*, with 7.89, although no appreciable differences exist between sectors, all values being higher than 7 points. See Figure 10-23.

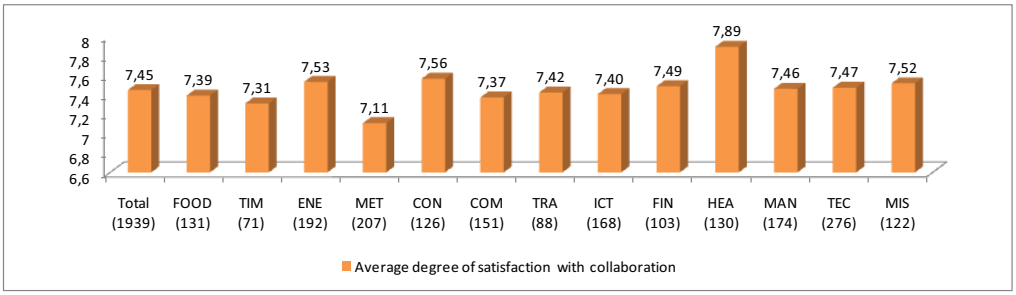


Figure 10-23: Average degree of satisfaction in collaborations with Universities or RC, by sector.

By company size

Division according to company size reveals no appreciable differences as to one group or another. See Figure 10-24.

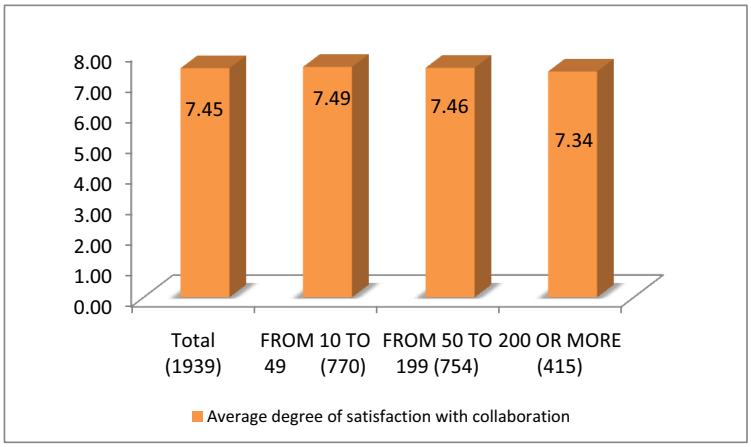


Figure 10-24: Average degree of satisfaction in collaborations with Universities or RC, by company size.

10.3 Interest in contacting i-MATH

Question C31 in the questionnaire asked if *companies were interested in receiving a visit from an i-MATH technical expert.* This question was posed to those companies stating their need for assistance in CAD/CAE or ST/OR as well as those that used OMT, a total of 1,075 companies in all.

Figure 10-25 shows that 34% of these companies are interested in contacting i-MATH, which amounts to a total of 366 companies.

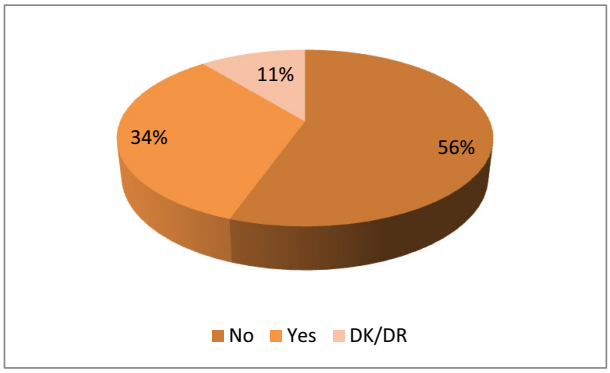
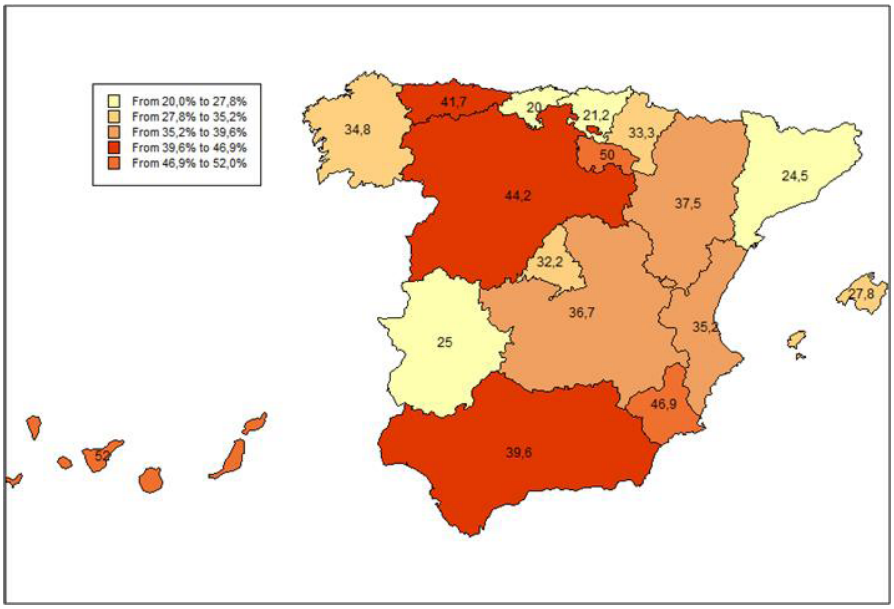


Figure 10-25: Companies interested in contacting i-MATH (n=1,075).

By Autonomous Community

Map 10-2 shows that the Autonomous Communities most interested in receiving a visit from i-MATH are the Canary Islands, La Rioja, Murcia, Castilla-León and Asturias, all with figures higher than 40%. Note that this question was posed to only four companies in the community of La Rioja (Table 10-4), so that the 50% that appears on the map corresponds to two companies only. The Basque Country and Cantabria yield the lowest figures of around 20%. In Cantabria, the question was posed only to the five companies that had expressed some type of requirement for mathematical tools. See Table 10-4, which shows the sample in each Autonomous Community.



Map 10-2: Companies interested in contacting i-MATH (n=1,075).

Auton. Com.	Interested in contacting i-MATH
ANDALUCÍA (144)	39.6
ARAGÓN (32)	37.5
ASTURIAS (24)	41.7
BALEARIC ISLANDS (18)	27.8
CANARY ISLANDS (50)	52.0
CANTABRIA (5)	20.0
CASTILLA-LA MANCHA (30)	36.7
CASTILLA-LEÓN (43)	44.2
CATALUÑA (188)	24.5
COMUNIDAD VALENCIANA (105)	35.2
EXTREMADURA (8)	25.0
GALICIA (69)	34.8
MADRID (239)	32.2
MURCIA (32)	46.9
NAVARRA (18)	33.3
BASQUE COUNTRY (66)	21.2
LA RIOJA (4)	50.0
Total (1,075)	**33.9**

Table 10-4: Companies interested in contacting i-MATH (n=1,075).

By sector

When the sample is divided according to sector, the highest percentage of companies prepared to receive a visit from i-MATH correspond to *Metal and machinery,* with 44%, *Food and clothing,* with 39%, and *Timber and paper* and *ICT*, with 38%. See Figure 10-26.

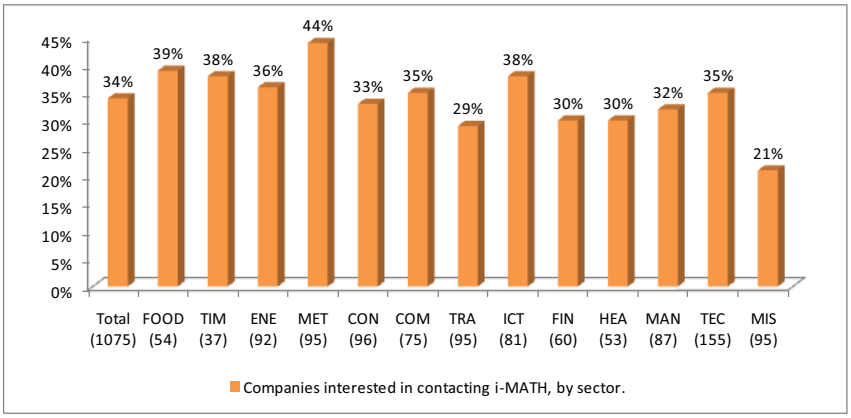


Figure 10-26: Companies interested in contacting i-MATH, by sector (n=1,075).

By company size

Division by company size reveals no appreciable differences, with only 2% more for large companies compared with small firms. See Figure 10-27.

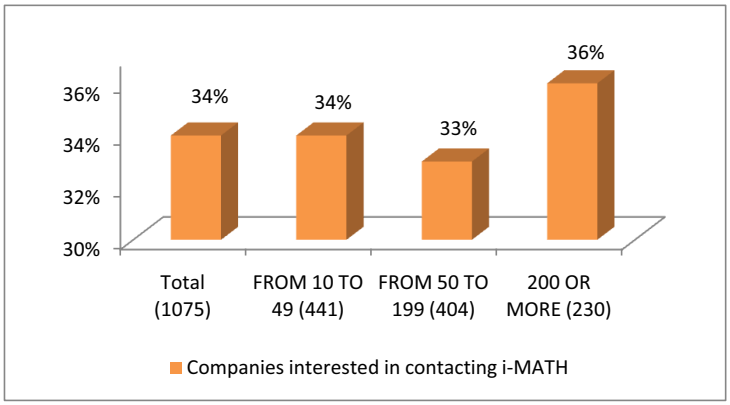


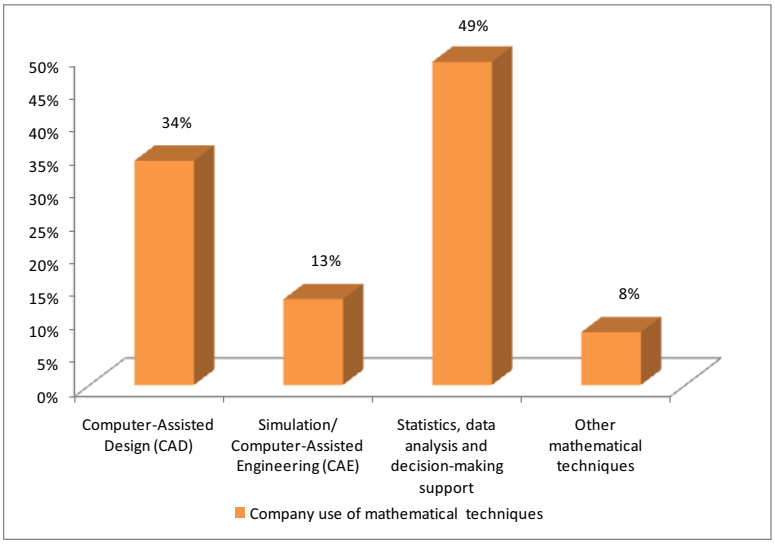
Figure 10-27: Companies interested in contacting i-MATH, by company size (n=1,075).

11 CONCLUSIONS

This document contains the analysis of a survey about the business and corporate demand for mathematical technology, conducted on the basis of 6,716 companies from all over Spain. It has enabled us to detect the needs and problems in the different Spanish business sectors where mathematical techniques could constitute a fundamental or complementary tool; knowledge of the use of and demand for mathematics, as well as attracting the interest of companies with a view to some type of collaboration with Universities or Research Centers.

The criteria for selecting the sample size by stratum, taking into the account the population distributed according to company size as well as by sector and by Autonomous Community are defined on the basis of the experience in technological transfer by the Map's Panel of Experts in order to ensure a reasonable representation of the sectors and sizes of the companies regarded as the most strategic for this study.

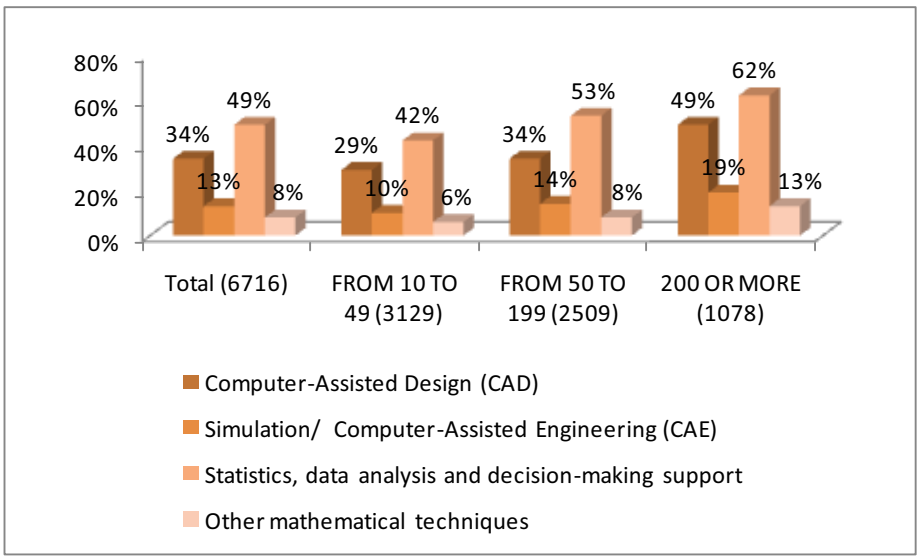
By means of this study it has been possible to determine the level of implantation of mathematical techniques in companies and businesses, which is summarized in the following graph:



Thus, in first place, with a figure of 49% of all the companies surveyed, is the use of *Statistical techniques* and *data analysis or decision-making support techniques*, which find their highest degree of implantation in the *Commerce* sector (65%), although the percentage difference between sectors is not particularly pronounced. These techniques are used above all for *Customer analysis* and *market or product studies*. In addition, only 7% of the companies surveyed stated their need for assistance in this sphere, and curiously the greatest demand here is also for use in *Customer analysis*

and *market or product studies*. It is worth pointing out that 38% of companies with more than 200 employees say that they do not make use these types of techniques, which ought to be implanted to a greater or lesser extent in companies of this size. In second position is the use of *Computer Assisted Design* (CAD), which is used in 34% of the companies surveyed, particularly in the *Metal and machinery* sector. In third position, and with values considerably lower, is *Computer Assisted Engineering* (CAE) with 13%, the greatest degree of implantation once again being in the *Metal and machinery* sector. In half the cases, CAE is used for conducting *Mechanical or structural calculations*. Requirements in CAD/CAE are found in 3% of companies, the highest levels being in the *Metal and machinery* sector*;* as regards the type of requirement, more than half of such firms state their need in for *Information or assessment about the applicability of CAD/CAE in the company*. In last place with 8% comes the use of *Other Mathematical Techniques*, with double this percentage in the *Technical services and Information and Communications Technology (ICT)* sectors. In half of the companies, these techniques are used for the processing of *Digital images*, and in almost 40% for the *Design of geographical location systems such as GIS or GPS*.

Below is an analysis of the different uses of each of the mathematical techniques analyzed in this document according to company size:



In the case of all the techniques, the larger the company the more extended is their use: the use of CAD techniques in large companies exceeds that in small companies by 20% and in medium-sized firms by 15%; similar percentages are found for Statistical Techniques and Operations Research. However, this difference is narrower where CAE and the use of Other Mathematical Techniques are concerned. The effort that many small companies are making to incorporate these tools into the course of their work is remarkable, as the corresponding percentages for their use so eloquently demonstrate.

The percentage of companies expressing willingness to collaborate with Universities or Research Centers is noteworthy (32%). This percentage is similar to that of those companies that have already collaborated in the last five years (31%), such collaboration mainly taking place in areas of training; the degree of satisfaction expressed by the companies involved in these collaborations and that have scored them as notable is encouraging; more than half of such firms would be prepared to collaborate again.

As regards human resources, 8% of companies have mathematicians or statisticians on their staff; in half of the cases these employees are engaged in *Statistics*, *data analysis*, *decision-making support and Business informatics or systems*. 5% of companies state that they require mathematical services or personnel qualified in Mathematics or Statistics.

In general, companies in the study perceive the importance of mathematical techniques, and 34% would like to be contacted by technical experts from i-MATH Consulting.

The most outstanding conclusions are summarized as follows:

1. The first conclusion to be drawn from the survey is that there is a good level of implantation of mathematical knowledge, and that companies are aware of this; we believe that the reality of this situation is not justly appreciated by the community of researchers in mathematics, where it is often thought that mathematics are far removed from the industrial and business world.

2. It is difficult to evaluate to what extent the use that companies make of mathematical techniques goes beyond the purely instrumental (the use of spreadsheets or standard statistical packages in their most basic functionality, for example). This difficulty arises from the fact that the interlocutors who responded to the survey do not necessarily appreciate this type of distinction.

3. The implantation of statistical techniques, data analysis or decision-making support techniques is widespread, and the same can be said for CAD techniques (these latter being more closely linked to the industrial and manufacturing fabric).

4. It is also difficult to evaluate the influence of techniques such as CAE, and even more so those techniques categorized in this study under the heading of Other Mathematical Techniques. Apart from the fact that they deal with narrower fields than, for example, Statistics, the reason for this is that their definition is not as clear as in the case of CAD, which makes it more difficult to be sure that this type of knowledge has been clearly detected in the companies surveyed.

5. There is a further difficulty regarding Other Mathematical Techniques, and that is that such techniques are frequently mixed with other types of tools (especially in informatics), which makes their separate perception in companies difficult.

We consider this to involve both a difficulty in the understanding of the role of mathematics and a reflection of a very real situation: mathematics are becoming increasingly interdisciplinary and appear in contexts in which they are difficult to separate from other spheres of knowledge.

6. It is very important to point out that a good percentage of companies are prepared to collaborate with universities and other research bodies.
   Even more noteworthy is that most of these companies have previously entered into this type of activity in recent years. The conclusion seems clear: if these companies have collaborated once and have been satisfied with the results, then they wish to repeat the experience. Further efforts must thus be made to overcome the obstacle posed by what appears to be a lack of knowledge in other companies about the possibility of conducting such collaboration.
   It is necessary to make the most of the End-of-Course Projects carried out by new mathematicians, as well as Post-graduate projects and even Doctoral Theses, in order to bring about closer relations with companies, such as those that are being successfully achieved in engineering studies. Experience shows that these types of timely relations, linked to higher education and training, can lead to fruitful collaboration in the field of innovation and even in research.

7. Surveys do not appear to be a sufficiently refined tool for determining if companies really require additional mathematical techniques to those that they already employ. This deficiency may be mitigated by subsequent direct interviews by means of which a number of companies have expressed their interest in acquiring such techniques.
   It is even more difficult to find out if companies require personnel with mathematical qualifications, in a sense that goes beyond techniques and tools and involves the skills possessed by such personnel (capacity for abstract thought, problem-solving, etc.). Data on the number of qualified mathematicians and statisticians currently employed by companies are vague, since it has proved difficult to extract from the replies what the type of tasks these employees may be engaged in.

As a final thought arising from this study, it is necessary to remark that there still remains a long way to go to bring mathematical technology to a greater number of companies, and, above all, that cases in which this been successfully achieved should be made more widely known in order to increase company receptivity to this need, since at present only a small number of companies are aware of its potential.

Through i-MATH, training courses specializing in and aimed at specific sectors should be defined, forums set up and informative meetings organized on the applicability of the mathematical techniques analyzed in this survey, and modeling weeks or similar workshops fomented, in which companies would be able to interact with specialists in order to address problems of particular concern, etc.. In order to break through the barrier that currently separates universities and companies, some of these activities should be carried out in areas of direct company concern, either by making the most of technology park structures, clusters of companies in a particular sector, or chambers of commerce, etc..

INDEX OF FIGURES and TABLES

TABLES

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